JUNEAU ICE FIELD RESEARCH PROJECT, ALASKA

1950 SUMMER FIELD SEASON

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J.I.R.P. Report No. 7 September, 1954

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FOREWORD

A summary report of the work of the 1950 season of the Juneau Ice Field Research Project is given in the following pages. It is the third in a series of quantitative field contributions to the integrated long-range study of the Juneau Ice Field.

During this season, the glaciological investigations conducted in 1948 and 1949 were extended and some new and specialized research undertaken pertaining to the physical character of glacier ice and its snow and firn cover. A few of the climatological, geomorphological, and ecological investigations were continued and the network of local triangulation stations was enlarged and the previous ground control refined. Additionally, in the glaciological and meteorological program, a few reconnaissance investigations were conducted to help in planning future special research on the ice field.

The primary purpose of this report is to present the basic scientific data resulting from this season of field work together with representative charts and diagrams and sufficient discussion to make them meaningful for current use. Some preliminary interpretations are made to provide comparison with the reports of previous and subsequent expeditions to this area and to coordinate with the more complete analyses to be presented in special reports and articles in scientific journals. Some suggestions for improving field techniques and for extending certain of the scientific studies are also presented.

Only brief mention is made of the investigations conducted in regard to equipment, food and logistic activities in support of the project, since these have been covered in some detail in other reports. The value of these phases of the program, however, should not be underrated in view of the resultant training of personnel and the improvement of field techniqies.

The editorial and stenographic assistance of my wife, Joan, and of Mr. John Howe and Miss Marian Moore of the American Geographical Society is gratefully acknowledged.

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I. INTRODUCTION

Glaciers have been classified geophysically into two categories: (1) polar and (2) temperate (Ahlmann, 1935, p. 102). In the first type, except for seasonal atmospheric variations affecting a shallow surface zone, internal temperatures are sub-freezing; whereas in the second, they are generally at the pressure melting point. In polar glaciers, therefore, melt-water is only a surface phenomenon occurring for a short period in the summer season. In temperate glaciers, melt-water plays a more dominant role in englacial regime with a greater degree of percolation into the firn and drainage from the deeper levels often continuing throughout the year. In a single glacier system extending from high to low elevations, it has been shown that thermic conditions representing each of these categories can exist (Hughes and Seligman, 1939, pp. 631-32).

Richard F. Flint, in his book "Glacial Geology and the Pleistocene Epoch" (1947) considers that temperate glaciers are typical of the inland glaciation which covered most of Europe, northern North America and Siberia during the expanded stages of the Pleistocene. Dr. Hans W:son Ahlmann, the eminent Swedish glaciologist, has expressed the opposite view. It is probable that both polar and temperate ice co-existed across the vast continental glacier sheets during the periods of their maxima. On this latter thesis, a detailed study of either type will yield data pertinent to a better understanding of the character of each and to the broader aspects of ancient as well as present-day glaciation.

Today, temperate glaciers are typical of south coastal Alaska where the largest areas of existing glacier ice outside of Greenland and Antarctica are to be found. Thus, Southeastern Alaska is an excellent locale for this type of glaciological research. During the past three-quarters of a century, numerous more or less descriptive studies of glaciers have been conducted along the Alaskan coast. Most of these, however, were carried out by observers who visited only the various ice termini at or near sea level. Necessarily, these investigations have been quite limited in nature as well as extent and emphasized only the cartographic aspects. Such continued measurement of changing termini without study of related morphological and meteorological features in the source regions could result only in partial and inadequate answers to the glaciological problems. To understand fully the relationship of these ice masses to former ice epochs and to ascertain the nature and extent of Pleistocene glaciation in these regions as well as results of the post-glacial climatic amelioration, it is necessary to investigate systematically all pertinent scientific aspects of a representative system of modern glaciers. With this in mind, the Juneau Ice Field Research Project was formulated.

The Juneau Ice Field, one of the largest remaining centers of highland ice on the North American continent, is uniquely situated to serve as a field laboratory for such a long-term integrated research program. Lying on the longitudinal axis of the Alaskan Coast Range, with the center of the region at latitude 58°40'N., it embraces nearly 1000 square miles of interconnected glaciers and highland névés and thus affords an opportunity for the thorough study of various phases of the glacier sciences both at low elevations and at the upper levels. The accessibility of this area is one of its advantages. The project's main base camp, situated near the center of the ice field, is only 25 air miles north of Juneau, the capital city of Alaska. Excellent air field facilities for contact flying out of Juneau, the instrument airport at nearby Gustavus, and sea-plane facilities in Gastineau Channel at Juneau have all served for the loading and embarkation of the government and civilian aircraft which have supported the project. Several usable routes have permitted personnel to reach the area on foot, as the southwestern fringes of the ice field lie only about ten miles from the city limits. The nearness of river boat facilities and the availability of a major center of expeditionary supply at Juneau have also simplified the problem of logistics.

An additional advantage is that a longer record of standard meteorological observations in proximity to an ice field exists in this area than at any other glacier locality in America. One nearby station has records as far back as the 1880's and, at present, is operating upper air recording equipment. These data, of course, are of great aid in correlating the meteorological records obtained at the various temporary stations on the ice field. The number of significant glaciological problems and opportunities for important fundamental field research in this region of highland ice further set it off as a unique and extremely interesting locality for a long-term scientific program. On the Juneau Ice Field, therefore, is an opportunity to develop quantitative glaciological research over a period of many years.

The essential objective of the 1950 program was to continue the scientific investigations begun in 1948 and 1949 with the primary concentration on investigations of the physical character of temperate glacier ice and its annual snow cover. This program included studies of the firn and englacial structure and movement as well as aspects of the regime and climatology of the ice field. In addition, plans were laid to extend some of the climatological, geological, geomorphological and ecological investigations and to enlarge the network of local triangulation control for an eventual detailed mapping of the glaciated area.

II. SUPPORTING AGENCIES AND ACKNOWLEDGMENTS

As in 1949, the primary sponsors of the project were the Office of Naval Research (under Task Order N9onr-83001) and the American Geographical Society. Aerial logistic support was provided by the Departments of the Navy and the Air Force through the cooperation of the National Military Establishment. Special acknowledgment is given to the Alaskan Sea Frontier of the U. S. Navy for making available an aircraft and crew from the Naval Air Station at Kodiak. Appreciation is accorded the Alaskan Air Command for the excellent support rendered by its 10th Rescue Squadron from Elmendorf Air Force Base. The Department of the Air Force helpfully supplied invitational flight orders for the use of project personnel traveling to and from Alaska. In addition, certain otherwise difficult to obtain equipment was made available by Air Force units (under Bailment Agreement A.F. 33 (038-6114). The Air Materiel Command loaned 60 twenty-four foot cargo parachutes which were indispensable in the aerial delivery of supplies to outlying camps on the ice

field. The Army Quartermaster Corps, the Signal Corps and the Medical Corps each provided a variety of useful stock equipment for field use and test as well as some special instruments for the scientific work. The Army Corps of Engineers and the Army Ordnance Department supplied the project respectively with a large fuel storage tank and two oversnow vehicles. A report on the operation and use of these and other items of equipment has been prepared and distributed to the agencies concerned. (J.I.R.P. Report No.5).

Considerable help in the development and organization of the meteorological program and in the working up of the climatological summaries was given by the Juneau Office of the U. S. Weather Bureau, especially through the kind cooperation of the meteorologist-in-charge, Mr. C. V. Brown. Through the interest of Mr. Glen Jefferson, Regional Director at the Weather Bureau's Territorial Headquarters Office in Anchorage, certain requisite meteorological equipment was provided. A recording radiation unit was made available by Weather Bureau headquarters in Washington, D. C. and helpful advice concerning the evaluation of records was given by its Solar Radiation Field Testing Station in Boston, Massachusetts. Dr. Wallace E. Howell, Director of the Mt. Washington Observatory; Professor Charles F. Brooks, Head of the Blue Hill Meteorological Observatory at Harvard University; and Colonel Marcellus Duffy, Commanding Officer of the 2107th Air Weather Group at Anchorage, Alaska, gave advice and made available experienced members of their staffs for the field party. Major R. T. Derr and Major H. G. Dorsey, Jr., of the Arctic Weather Central, were also especially helpful.

The U. S. Geological Survey provided a series of englacial temperature recording cables and accessory equipment as well as advice on the geological program. Acknowledgment is made especially of the help of Dr. J. H. Swartz, geophysicist-in-charge of the Geological Survey's Baltimore Field Unit. The Navy Hydrographic Office and the Woods Hole Oceanographic Institute supplied other special equipment. The Alaska Territorial headquarters of the U. S. Forest Service (Tongass National Forest), through the good offices of Mr. B. Frank Heintzleman, Regional Forester,[1] and his chief assistant, Mr. Charles Burdick, also made available a local headquarters and warehouse space for the project and provided certain needed equipment and transportation facilities for personnel and supplies. The Forest Service also kindly allowed one of its Lands and Recreation staff members to assist in some of the field work and to aid in the expedition's liaison needs in Juneau. Mr. A. Francis, communications manager, and his staff, at the Airport Station of the Civil Aeronautics Administration very kindly volunteered to handle the radio schedules which were necessary in conjunction with the operations of supporting aircraft. This station also assumed the responsibility for thrice-daily radio schedules for relay of messages and weather data between Juneau, the Weather Bureau Office and the central research station on the ice field.

[1] Mr. Heintzleman has since become Governor of Alaska.

The project is especially indebted to the E. J. Longyear Co., of Minneapolis, Minn., for the loan of several tons of special core-drilling equipment and to Dr. Henri Bader, of the Engineering Experiment Station at the University of Minnesota, for his advice and help in the organization of this aspect of the research program. The Longyear Company also made available the invaluable field services of Mr. A. K. Anderson, an experienced driller on its staff, to supervise the glacier drilling program. The Eastman Oil Well Survey Co., of Denver, Colorado, materially aided the program by loaning bore hole survey equipment and supplying advice and help in plotting results. The Geological Society of America aided with a field grant for the purchase of accessory equipment for the bore hole investigations.

Grateful mention is made of the following persons and agencies who contributed in other ways to the work of the 1950 season: Dr. Paul Siple, Logistics Division, Headquarters, General Staff, U. S. Army; Major Victor Genez, Geophysical Sciences Branch, the Directorate of Research and Development, Headquarters, U. S. Air Force; Dr. Andrew Thomson, Controller, the Air Services Meteorological Division, Canadian Department of Transport; Dr. John Reed, Dr. H. R. Joesting, and Dr. G. R. MacCarthy of the U. S. Geological Survey and W. S. Twenhofel, E. Stejer and R. Marsh of the Juneau Office of the Geological Survey; Dr. J. L. Kulp and the Lamont Geological Observatory of Columbia University's Department of Geology; Colonel Bernt Balchen, special Arctic Adviser to the Alaskan Air Command; Major R. A. Ackerly, Acting Commanding Officer and Captain R. Holdiman, Operations Officer of the Air Force's 10th Rescue Squadron; Dr. L. O. Quam, Head of the Geography Branch of the Office of Naval Research; the management of the Polaris-Taku and Big Bull Mines near Tulsequah, B. C.; the staff of the Hotel Juneau; the owners of Taku Lodge and the following individuals in Juneau and Taku Valley areas: G. Bacon; L. Batton; E. S. Blackerby; R. Davlin; L. de Florian; G. George; E. Geurin; D. Gray; G. Gray; J. M. Greany; G. Haen; M. Hardy; E. Keithahn; G. Kirkham; M. Majuris; E. O'Reilly; R. O'Reilly; S. Owen; F. Parsons; and W. Youpie.

Acknowledgment is also made to the Commanding Officer of the Seattle Port of Embarkation and to J. Bryson, O. R. Miller and E. S. Bingham, who gave invaluable assistance in the routing and special handling of supplies through the Port, and to Colonel J. D. Alexander of the Alaska National Guard in Juneau for making available warehouse space for the oversnow vehicles during the winter of 1950-51. Mention is also made of the fine cooperation of the pilots and management of the Alaska Coastal Airlines and Alaska Airplane Charter in connection with the charter flights necessary for the transport of supplies and personnel.

Finally, appreciation is extended to the members of the project itself and especially to those volunteer workers and assistants who so willingly gave of their time and interest to the program. Acknowledgment is also given for the advice of Mr. W. O. Field, of the American Geographical Society, with whom the writer worked out the original ONR contract program, and to Miss C.I. Dempster and Miss Barbara Nelson for their secretarial assistance to the writer during the planning stages of this expedition.

III. PARTICIPATING PERSONNEL

The project was fortunate in having a number of persons who were willing to donate their interest, time and efforts to the program. A total of 29 men, eleven of whom had participated in the previous two expeditions, actively participated in the research work. In addition, six non-scientific visitors and part-time participants visited the ice field for short periods. As a nucleus of expedition personnel, twelve men spent from two to four months on the ice field. These included two glaciologists and one assistant, two geologists, four meteorologists, two surveyors and one medical doctor. All the other men in the party averaged from one to six weeks in the field and represented the several sciences shown in the list of project personnel and their affiliations given in Appendix A. Included in this list are several persons of a separate though supplementary field party which conducted ecological investigations near sea level on the west side of the ice field. This unit was under the organization and direction of Professor Donald B. Lawrence of the University of Minnesota. Maynard M. Miller served as project officer and leader of the field party.

Scientific advisers and special observers who visited and actively participated in the expedition during August and September included: Professor Robert L. Nichols, Head of the Department of Geology, Tufts College; Professor Peter Misch, Department of Geology, University of Washington; Dr. Henri Bader, Scientific Adviser to the Snow, Ice and Permafrost Research Establishment of the Army Corps of Engineers; Dr. Louis O. Quam, Head of the Geography Branch, Office of Naval Research, and Mr. William O. Field Head of the Department of Exploration and Field Research of the American Geographical Society. The availibility of ski-wheeled C-47 aircraft from the 10th Rescue Squadron facilitated the arrival and departure of these men and other members of the field party. Throughout the summer, approximately 40 Navy and Air Force flight officers and air crew men were involved in the various logistic air operations. Many of these men willingly helped in the packing of supplies and parachutes and in the oftimes arduous task of loading and unloading heavy equipment at the Airport and on the ice field. The names of military personnel who participated are listed in Appendix A-IV.

Five men from Juneau volunteered to aid the scientific work and actively participated in the field from one to three weeks. Among these were Anthony Thomas, the U. S. Forest Service representative, who throughout the summer also rendered invaluable assistance in a part-time liaison capacity in Juneau. Dean Williams, an amateur radio expert, visited the ice field to check and calibrate the communication equipment at the central camp. Edward Browne and Thomas Stewart helped in the winterizing of equipment on the ice field and in the evacuation of the field party at the end of the season. Kenneth Loken kindly made available his light airplane and skilfully piloted it in connection with special flights for various purposes in aid of the project.

IV. AERIAL LOGISTICS

All supplies, with the exception of a small amount of back-packed personal equipment, were delivered to the ice field by aircraft.

The first supplies (rations for the advance party) were free-dropped by light aircraft at the central research station on June 24th. This was supplementary support prior to the arrival of the military aircraft scheduled to deliver the bulk of equipment and expedition supplies. On June 26th, an R4D Naval airplane under the jurisdiction of the Alaskan Sea Frontier arrived from Kodiak to commence the first of eight flights to the ice field. By July 3rd, these flights had been completed and six tons of supplies had been delivered to eight separate camps (Camps 10, 10B, 4, 8, 12, 14, 15 and 16.) (See Fig. 2) Five of these camps were newly established, two of them being supplied with basic camp equipment primarily for the use of the project in the following year. During this early summer aerial operation by the Navy, 24 parachute loads were delivered averaging 200 pounds per unit. In addition, on the 8th of July, another 800 pounds of equipment in four parachute loads were delivered by commercial Grumman aircraft to Camps 16, 10 and 4. Later in the summer, nine more parachute deliveries were made by Air Force C-47 and B-17 aircraft thus bringing the total number of parachutes used in this season to 37. During the summer, approximately 300 free-fall bundles were dropped by commercial and military planes. (For details, see J.I.R.P. Report No. 5, Table IV, p. 6.).

During the height of the Navy support, an Air Force C-47 equipped with ski-wheels also arrived in Juneau to make a series of six ski-landings over a three-day period ending July 2nd. The purpose of these flights was to transport heavy drill equipment and fuel supplies to the Taku Glacier névé. At this time, a veritable shuttle relay of these two aircraft took place with the Navy cargo aircraft handling all packaged units for parachute and free-fall deliveries and the Air Force ski-wheeled plane handling the heavy items which could not have been delivered otherwise. The Air Force plane transported ten tons of supplies and equipment during the early summer period in six flights supplying the two main ice field camps (Camp 10 and 10B). In addition, seven of the expedition personnel were flown to the central station. The two aircraft returned to their bases on the 3rd of July. The services of the Navy plane were not required again during this season.

Aerial support was planned on the basis of a mid-summer as well as an early summer set of ski-aircraft supply flights. Thus, a group of landings was initiated during August. The main purpose of these flights was to transport several specialists and senior advisers to the ice field. A C-47 aircraft was made available for this use for a period of several weeks. Between July 31st and August 23rd, eight ski-landings were made and two air drop flights involving four parachute loads. In this mid-summer operation, seven more tons of supplies and equipment were taken to the upper Taku Glacier. At the end of the field season, a final set of five landings was made to bring in food and gasoline to be stored at the central station for subsequent use and to evacuate nearly five tons of scientific equipment, records and personnel before the first heavy autumn snow falls made it difficult to operate large aircraft on the upper Taku Glacier.

With the Air Force planes, a total of 24 flights was made to the ice field and 19 landings accomplished on the glacier surface at Camp 10B (elevation 3600 ft.). Most of the take-offs with the ski-wheeled aircraft were effected with the use of JATO (rocket) cylinders attached to the underside of the fuselage. At the end of the season, because of the hardened snow surface, five take-offs were possible without JATO. In two of these, the plane carried a take-off load of 4000 pounds. In early and mid-summer, however, JATO was almost always essential.

In summary, 32 round-trip flights were accomplished by Navy and Air Force planes in support of this season's expedition. Of the non-military aircraft flights, several were made by Kenneth Loken in an Aeronca Champion. Ten supporting flights were also made by Belanca, Grumman, and Aeronca aircraft chartered from Alaska Coastal Airlines and Alaska Airplane Charter Co. These permitted the transport of personnel to and from the Taku Valley and the supplementary delivery of one ton of supplies and mail to several of the highland camps. The total aerial transport of supplies to the ice field in 1950 was 26 tons, four tons of which were delivered by parachute, six tons by free-fall and sixteen tons by heavy ski-equipped aircraft landing on the upper Taku Glacier.

V. GROUND ACTIVITIES AND CAMP ARRANGEMENTS

Members of the expedition arrived in Juneau on the 15th of June to purchase locally the requisite commercial supplies and to sort and package equipment which had been freighted from Seattle by the Alaska Steamship Company. The first unit to leave for the ice field consisted of three men who, on June 20th, traveled via Twin Glacier Lake to Camps 4 and 10. On June 22nd, the central research station was re-opened and the meteorological observations begun. The main cabin was found to be in good condition although a few minor repairs were necessary to the roof where portions of the aluminum sheathing had been ripped off by wind during the previous winter. Thrice-daily radio schedules were initiated on June 23rd with the Civil Aeronautics Administration station in Juneau. On this date also, the glaciological records were begun at Camp 10 and at 10A on the Taku névé.

While the initial group remained at the central station to receive the organized air drop of supplies, the other project personnel handled packaging and loading of the equipment to be carried by the Navy and Air Force planes operating out of the Juneau Airport. Continually good weather permitted the early season logistic requirements to be fulfilled with a minimum loss of time so that on June 30th three men were flown to the ice field to join the group at Camp 10. On July 1st, Camp 10B, near the glacier airstrip, was established and the meteorological and glaciological records commenced at that site.

On July 4th, four more men left Juneau for the ice field via Lemon Creek Glacier. Enroute, they consolidated the supply drops at the proposed site for Camp 16. The three remaining full-time members departed for the ice field on July 8th via a new route up the west side of East Twin Glacier. All members of the main party were soon thereafter assembled at Camps 10 and 10B to concentrate on the coordinated glacio-meteorological program. Dr. and Mrs. Lawrence arrived in Juneau on July 12th and with the help of one member of the ice field party immediately began the low level ecological studies.

During the last three weeks of July, continual fog and heavy rain prevailed. The rains were accompanied by relatively warm temperatures on the glacier surface so that by the last week of July ablation had proceeded to a point where a number of crevasses had become exposed at Camp 10B and between Camps 10B and 10A. This condition created a few operational difficulties and required all further ski-landings to be effected a quarter of a mile west of the original landing site at 10B. Restricted visibility prevented the mapping and survey program from getting underway until July 21st. This stormy period was nevertheless used to good advantage for other aspects of the season's work. Englacial firn studies at Camp 10B progressed uninterruptedly and were, in fact, aided by the opening of the crevasses (see Fig. 4). Also, under the direction of Merritt and Turner, the permanent facilities at the research station were enlarged and improved. A pre-cut, 6 x 10 x 10 ft. shed was built onto the back of the main cabin to serve as a transceiver room for communication equipment. This structure, which also served as a separate bunk house and office space for the senior meteorologist, was insulated for future winter use. An aluminum shed for sanitary convenience was constructed in the vicinity of the station and a larger and more sturdy radio antenna tower was fabricated out of lumber which had been flown in for this purpose.

On July 20th, Professor Misch arrived on the ice field via the route from Twin Glacier Lake. After remaining in the area for a week to observe and advise on some of the geological work, he returned to Juneau. The other senior advisers, Professor Nichols and Dr. Bader, who actively participated in the latter half of the season's work, were flown to the ice field in the August C-47 flights.

Between July 31st and September 6th, the investigations at Camp 10B were highlighted by the glacier drilling program. A wooden-ceilinged laboratory was dug into the firn near the proposed core drilling site. In this laboratory, the petrofabric analysis of ice cores was conducted.

Since the glacier air strip was at Camp 10B, this camp became the main staging depot. From three to 22 men were encamped at this site at various times during the summer. Seven hexagonal tents were erected as sleeping quarters. Three other hexagonal tents and two 12 x 14-ft. wall tents (on loan from the U.S. Forest Service) were used for storage and for cooking and messing. To reduce ablation effects, all tents were placed in shallow pits dug to the proper ground dimension. Each was lined with plywood or planked with 2 x 12 in. floor boards to make the accommodation more comfortable. A sketch view of the camp and equipment layout at 10B is shown in Figure 4a.

The only other camp occupied for any length of time during this summer was Camp 16 which was established on July 5th. Meteorological records were maintained at that site intermittently between July 14th and August 16th. Daily schedules were maintained with SPF and SCR-300 radios, operating at Camps 10, 10B, and 16. In this way, the requirements of each station could be filled when need arose and a check could be made on the progress of work and the morale of personnel.

In the latter half of the summer, the geology and survey teams used the caches at Camps 4, 9, 11A, 12 and 14 and also consolidated equipment which had been dropped by the Navy R4D at the proposed sites for Camps 8 and 15. A temporary camp (10C) was also positioned for glaciological work on a ribboned section of the upper Taku Glacier, one mile north of Camp 10.

The locations of all camps on the ice field are shown in Figure 2. A description of each camp site, its elevation, approximate coordinates and the year in which it was established are given in Appendix B.

Two M29C oversnow vehicles ("weasels") had been shipped to the project from the U. S. Army's Mt. Rainier Ordnance Depot, Tacoma, Washington. It was hoped that by dismantling them into component parts, they could be loaded into the fuselage of the C-47 ski-plane and flown to the ice field. Unfortunately, after four days of tedious effort dismantling one of the machines, it was found that the largest section was two inches too wide for the door of the aircraft. To transport it meant altering the inside of the fuselage which, under the circumstances, was not feasible. Thus, it was not possible to use these vehicles during the 1950 field season. Plans to drive them up the Taku Glacier during the winter 1951 expedition also were unsuccessful because of the field conditions to be encountered. The delivery was finally accomplished by para-dropping the vehicles from a C-82 aircraft in the summer of 1951. (A discussion of this operation is given in J.I.R.P. Report No. 5, pp. 34-36.).

In this season, therefore, all ground travel was by foot or skis and the relay of supplies between camps was accomplished with man-hauling sledges and by back-packing while on skis. The failure to deliver the "weasels" made it even more advisable to concentrate the scientific work at one or two primary stations. Except for travel necessary to the mapping and survey work and the geology and geomorphology studies, most long-distance travel was confined to the normal over-land routes between Juneau, Camp 10 and Twin Glacier Lake. The Camps 16 and Camp 4 routes (Fig. 2) were used equally for travel to and from the ice field.

In September, a small party descended into the Taku Valley from Camp 4 to spend a few days studying the recent terminal position of the Taku Valley glaciers and in reconnaissance observations of the geomorphology between the head of Taku Inlet and the terminus of Talsekwe Glacier. Several days were also spent in reconnaissance of the physiographic problems in the Taku River Valley northeast of Tulsequah, B. C., as far as Red Cap Creek, 17 miles beyond the International Border. (Fig. 2). This journey was supplemented by an observational flight to assess the distribution of river terraces near the junction of the Inklin and Nakina Rivers, and to consider the possibility of conducting related studies in that area in the future.

Ground evacuation of the expedition from the ice field was begun in the second week of September and was completed with the aid of the C-47 ski-plane on the 28th of September. Several members of the group remained in the area for one final week of low-level investigations and to inventory and store expedition equipment in the U. S. Forest Service warehouse. The last member of the season's field party left Juneau on October 5th.

VI. EXPEDITIONARY TECHNIQUES AND TRAINING

In conjunction with the scientific program, considerable experimentation was conducted in logistics and in the techniques necessary for living and successfully conducting field work on glacier and mountain terrain. This phase of the program is of practical interest and value to the supporting military agencies as well as to the field scientists. As part of this program, some useful testing of equipment and food was accomplished and a minor medical program undertaken. Comments and recommendations on these aspects, together with observations from the 1949 and 1951 field seasons, form the basis of a series of seven reports which have been combined into three recent publications.[2]

This season comprised 107 days of field work. Approximately 55 per cent of this time was spent directly on the scientific program, the remaining 45 per cent being devoted to logistical activities, necessary "housekeeping" details and ice field travel. This ratio of productive field time was higher than in the 1949 season. Four factors particularly contributed to this: (1) better general weather conditions; (2) scientific studies concentrated at two adjacent camps so that most work could proceed even when weather was inclement; (3) ski-plane landings made within a few yards of the main glacier study camp thus reducing the time necessary for transport of equipment; and (4) less time necessary for establishing caches and for construction work on the research station and other permanent facilities.

With the modest field laboratory which is now available and the network of supplementary camps established where equipment has been cached and between which the routes have been laid out and the logistical supply problems fairly well resolved, it is anticipated that the scientific program can be more expeditiously continued in the future with a minimum of time required for these corollary aspects. If the hopes and plans for further improving these facilities can eventually be accomplished, the per cent of time available strictly for scientific investigations should be further increased.

VII. ABSTRACT OF THE SCIENTIFIC PROGRAM

The primary objective in this season was to continue the glaciological investigations with secondary emphasis placed on related meteorological and survey data. Most of the geomorphological and geological studies were preliminary in nature and were undertaken to formulate a feasible outline and a sound basis for later detailed work. Dr. Lawrence's ecological program was designed to enlarge upon his 1949 research on one glacier at the southwestern edge of the ice field. The higher elevation ecological work was carried through only during the first half of the season. This has been supplemented, however, by more extended investigations in subsequent seasons.

[2] See J.I.R.P. Reports Nos. 3, 4, and 5.

In the glaciological program, continuing studies were made on internal glacier structure, on the rate and manner of melt-water percolation in the firn and in the vertical profile measurements of some of the physical characteristics of firn. Further records were obtained on ablation and accumulation, on the changing position of the névé line and on surface and englacial movement. The seven and one-half tons of deep rotary core drilling apparatus taken to Camp 10B in early summer facilitated investigations in the Taku Glacier and its firn cover to a depth of 292 ft. below the mid-August ablation surface. Petrofabric and air-bubble studies of ice cores taken from below 150 ft. were conducted in the cold laboratory dug into the firn near the drill site. Equipment necessary for the measurement of temperature in the firn was installed. This consisted of three sets of electrical resistance thermometers vertically spaced 1 to 20 ft. apart and implanted in drill holes reaching a depth of 170 ft. Measurements with these units were obtained in the following winter and summer seasons. In one of the bore holes, a 245-foot section of two-inch (inside diameter) aluminum pipe was inserted so that from future measurements of the deformation a record of differential englacial flow could be achieved. Inclinometer surveys on this pipe have been conducted in 1951 and 1952.

To provide correlation with meteorological data obtained at the central station, a weather observing post was established at Camp 16,on a nunatak ridge adjacent to the Lemon Creek Glacier névé on the southwestern side of the ice field. This site also served as a convenient route camp on the first stage of the three-day journey from Juneau to Camp 10. Camp 16 meteorological records have been supplemented by further data in the 1951 summer season. To enlarge upon the climatological records previously obtained above the névé line on the Taku Glacier, a meteorological program was also initiated at Camp 10B, which lies almost a mile nearer the center of the Taku Glacier (at approximately the 3600-foot contour) than the 1949 Camp 10A (Figs. 2 and 3). This site may be considered representative of the intermediate elevation névé surface on a main trunk glacier. These records are being compared with those from Camp 10 situated on a rock island at a 300-foot higher elevation and 1 mile to the northeast. At the mid-glacier station, a few preliminary micro-meteorological observations were made in order to formulate the basis for a more comprehensive program in 1951. At Camp 10, records were obtained of the duration of daily sunshine and diurnal variations in total sky and solar radiation. As in other years, all meteorological data have been collected for interpretation and comparison with the synoptic surface and upper air observations obtained at adjacent low-elevation stations of the U. S. Weather Bureau and the Canadian Air Services Meteorological Division.

In the survey and mapping program, approximately 500 square miles of ice field terrain were brought into a network of fourth-order local control. This coverage also included a re-occupation of already-established stations and a refinement of some sections of the previous year's survey. The field triangulations were obtained by theodolite and the stations accurately pinpointed on existing vertical aerial photographs. Local photographic stations were established at several key points on the ice field for panoramic reference, useful for studies of future volume changes in the névé area. The photographs may also be utilized for morphological interpretations during compilation of the ice field map.

A small amount of mapping on aerial photographs and some reconnaissance studies were conducted concerning the bedrock geology of several nunataks in the central portion of the ice field. A representative collection of rock samples was obtained for laboratory classification to supplement previous studies in the migmatite complex of this area.

In regard to the geomorphology of the region, a reconnaissance study was attempted on several deglaciated nunataks. These investigations were extended to the periphery of the glacial area in an effort to interpret the region's physiographic history. Much more field work needs to be done along this line; however, some useful information was obtained concerning the upper and outer limits of Wisconsin and recent glaciation. A few observations were also made on the nature of fluvial and glacio-fluviatile sedimentation in the Taku and Gastineau Valleys and on the fiord development and post-glacial emergence of this portion of the Alaskan coast.

In the ecological program, as in previous years, collections of upper elevation arctic and alpine plants were obtained from nunataks and other rock outcrops bordering the glacial area. These were supplemented by studies of the stratigraphy of local peat bogs and the constitution and depth of muskeg on raised benches nearer sea level. Pollen-analytical techniques were employed for the study and differentiation of annual increments of snow accumulation.

These investigations have been purposefully organized as part of a long-range program of record. Since all of them are as yet not complete, some of the data and information are merely listed or briefly mentioned in this report so that they will be readily available for future reference and interpretation together with additional seasons of record. Where this summer's special studies warrant it, the results are discussed in some detail. In those instances where final reports have not yet been received or have already been published elsewhere, a brief synopsis of the work is made and the reference to its published source is given.

VIII. GLACIOLOGY

The glaciological investigations in 1950 were organized so as to supplement the 1948 and 1949 records and also to introduce several new and previously unattempted lines of research. The main emphasis was on englacial investigations, using pit, crevasse wall and boring techniques. A few aspects of this summer's work which relate to the longer range scientific program are presented in other reports of this project. The pertinent references to these other publications are noted in the text.

A. General Glaciological Observations and Records.

1. Regime

To achieve a reliable assessment of the material balance of any glacier or ice field, a number of years of comparative records are required. Since a discussion of the annual névé surface economy and a treatment of measured details of firn regime on the Taku Glacier for some years previous will appear in a future report, only the briefest comments on the comparison of records are included in these present notes.

The regime studies undertaken are similar to those introduced by Professor H. W. Ahlmann (1948) in his investigations during the 1920's and 1930's of several glaciated areas fringing the North Atlantic. One phase of this research involves a detailed record of the amount and kind of snow accumulation at given locations balanced against amounts and kinds of ablation and wastage. Unfortunately, where only summer observations are available, certain assumptions must be made in order to evaluate the annual regime for a given year. If carefully done, however, the interpretations can have comparative value. For long-range relationships, the net increase or loss is usually expressed in terms of water equivalent, preferably as a deficit or surplus per unit area. With these data, there should be correlative information on the annual variations in position of the névé line and of any changes in position of the glacier front. The terminal records should be shown preferably as volume gains or losses instead of merely as horizontal distances of advance or retreat.

The 1949-50 budget year, at the 3600- to 3800-foot levels on both the Taku and Twin Glacier névés, showed no retainment of winter snow cover. Slightly negative conditions, or at least those nearly "in balance", may therefore be reported for this year at this elevation, where, in 1948-49, an annual surplus of 12.4 ft. of firn occurred. At the measured late summer, 1949 bulk density (0.55), this represented 82 in. or 208 cm. water equivalent. In 1947-48, there was a net surplus of approximately 34 in. (about 86 cm.) of equivalent water at the surface of the glacier. Thus, we may term these earlier two years as positive budgetary years at this level. The probable relationship between the net surpluses of seven previous years (since 1940-41) are indicated in Fig. 8, which is based on data obtained in the summer of 1950.

At the end of the 1950-51 ablation season, the yearly surplus-loss relationship was found to be even more severely negative than in the 1950 season, the net deficit being 23 in. (38.4 cms.) of water equivalent at the Camp 10B surface. Thus, a varied pattern of annual regime is already apparent. It is hoped that the record may be continued as frequently as possible in years to come so that an interpretation may be made not only of the present trend in the Taku Glacier but in the regime of the ice field as a whole.

2. Ablation

Continuous records of gross ablation were obtained at Camp 10B throughout most of the summer. Comparative records were also obtained from several other sites on the névé over shorter periods of time. Correlated with both earlier and subsequent records at these sites, these data permit an evaluation of the average length of the ablation season at specific elevations. From these data the mean seasonal rate and magnitude of névé gross ablation can also be determined. Such information can be not only of theoretical value but of practical use in foretelling surface snow conditions for oversnow vehicle travel and ski-aircraft operations.

Two types of ablation stakes were employed: (1) small, quarter-inch diameter fir dowels in 3-ft. lengths, reset into the firn surface each day and (2) rectangular cross-sectioned, white-painted wooden stakes (3/4 in. by 1-1/4 in. and 4 ft. long) which were implanted vertically in the snow to a depth sufficiently great to minimize settling effects. Measurements were normally taken twice daily at 0800 and 2000. The measurements were made either by marking the level of the snow surface on the stake with pencil (for subsequent tape measurement) or by directly measuring the distance from the top of the stake to the surface. Where possible, an average of readings on three stakes was obtained. All measurements were taken on the flattest sections of the névé to reduce errors introduced by differential ablation under irregular surface conditions. (see below)

Ablation records are given in App.C and Fig.5. To simplify these, an average summer bulk density of 0.50 was used for the calculations of water equivalent. For refinement of these calculations, one is referred to the density curves at the end of this report. Figures 5a and 5b illustrate typical 24- and 12-hour values and indicate the periods of maximum ablation as well as the end of the ablation season. Figure 5c also shows the comparison between gross ablation at three sites at approximately the same elevation on the Taku Glacier névé in mid-August. The relative positions of these sites- 10A, $10B_1$ and 10B are indicated in Fig. 3. Records from these sites show the marked decrease in ablation from the edge towards the center of the glacier.

Ablation near the center of the Taku Glacier averaged 1.30 in. of snow (0.65 in. water equivalent) per day during the full summer season with the maximum of 3.75 in. of snow (1.9 in. water equivalent) occurring on July 14th. The average daily ablation for each summer month appeared to decrease from a maximum at the end of June to a minimum in early September. These averages are noted for Camp 10B as follows:

June Last week	Average of 2.0 in. of snow ablation (0.90 in. water equivalent) per day (2000 to 2000). Night-time ablation on 3 days out of 7 with maximum of 1 in. per night (0.44 in. water equivalent)
July	Average of 1.52 in. of snow ablation (0.71 in. water equivalent) per day. Night-time ablation on 5 days out of 31, with maximum of 1 in. per night (0.49 in. water equivalent)
August	Average of 1.21 in. of snow ablation (0.62 in. water equivalent) per day. No night-time ablation.
September First 3 days	Average of 0.54 in. of ablation (0.29 in. water equivalent) per day
September Last 3 weeks	Negligible ablation in old snow. Most occurred in freshly fallen snow

The ablation season came abruptly to an end in the first week of September when 1 to 14 in. of new snow fell at levels from 3000 to 5000 ft. respectively. It is probable that a considerably greater quantity of new snow fell in the vicinity of Camp 8 (approximately 6000 ft.) during this period. This was indicated by the heavy blanket of fresh snow visible on the summits of all peaks in the area over 5000 ft. in elevation. Most of the accumulation, below the 4000-ft. level, ablated away in four days, as shown by the appended records (Sept. 6-10th). It was followed, however, by further heavy snows within a fortnight. These snows undoubtedly represented the first persistent autumn accumulation for the ensuing budget year.

3. Differential Ablation on Suncupped Snow Névé

In an effort to determine the relative magnitude of ablation on the crests and in the troughs of suncups a set of three flat-ruled increment stakes (graduated to sixteenths of an inch) and also three white-painted accumulation-ablation stakes were planted on the relatively level surface of the névé at 10B. Since these stakes had rectilinear cross-sections, two of each were oriented so that their narrow sides were in a southwest direction. This was to minimize direct insolation effects on the wood which was in contact with the snow. For comparison, the others were placed on an East-West line. The positions which these stakes held in respect to individual suncups are noted below. Their relative positions and orientation are also diagrammatically sketched in Fig. 6.

Positions of Micro-Ablation Stakes

Flat-Ruled Increment Stakes	Rectilinear Accumulation-Ablation Stakes
1. On flat divide between two suncups	4. On flat divide between two suncups
2. On ridge crest between two suncups	5. On ridge crest between two suncups
3. In suncup hollow (depression)	6. In suncup hollow

The relative form and range of size of suncups in this sector at the beginning of the period of observation are indicated in the sketch in Fig. 6. In each case, the suncups had a steep north-facing slope and a more gentle south-facing slope, giving an asymmetrical cross-sectional view. At the beginning of the following period of ablation measurements, the suncups varied from 8 to 26 in. across their longest dimension from crest to crest and the depressions were 3 to 12 in. deep. In the ensuing 12 days, the surface was more and more levelled with the result that the suncup pattern became very much less accentuated.

Table I

DIFFERENTIAL ABLATION RELATIONSHIPS ON SUNCUPPED NÉVÉ

(Camp 10B, elevation 3575 ft.)

Date Aug. 1950	Hour	Gross Ablation: Stake No.	Gross Ablation: Total Ablation (in.)	Gross Ablation: Increment (in.)	Water Equivalent (in.)	Gross Ablation: Stake No.	Gross Ablation: Total Ablation (in.)	Gross Ablation: Increment (in.)	Water Equivalent (in.)
8	1200				Set Stakes				
9	1300	1	3.0	3.0*	1.50	4	2.5	2.5	1.25
		2	2.25	2.25	1.13	5	2.63	2.63	1.32
		3	1.5	1.5	0.75	6	1.25	1.25	0.63
12	0800	1	10.0	7.0	3.50	4		6.0	3.0
		2	11.0	8.75	4.38	5		9.0	4.5
		3	8.0	6.5	3.25	6		6.0	3.0
14	1200	1	15.5	5.5	2.75	4		7.0	3.5
		2	17.0	6.0	3.00	5		9.0	4.5
		3	13.5	5.5	2.75	6		5.75	2.88
18	1730	1	21.5	5.0	2.50				
		2	23.5	6.5	3.25				
		3	19.5	6.0	3.00				
	1000					4		4.75	2.38
						5		6.75	3.38
						6		4.38	2.19
	1800					4		1.13	0.57
						5		1.75	0.88
						6		1.75	0.88
20	1120	1	24.5	3.0	1.5	4		1.75	0.88
		2	26.5	3.0	1.5	5		2.0	1.0
		3	21.5	2.0	1.0	6		3.75	1.88

*Underlined values (on flat inter-suncup divide) are considered as most representative of general ablation at this site.

The accuracy of measurements in the preceding table is considered to be within two millimeters of firn. It appears that the greatest ablation occurred on the sharper crests of inter-suncup ridges and was least in the hollows. The considerable variation between these portions of a suncup is best illustrated in the two series of plottings in Fig. 6. Between noon on August 8th and 1300 on the 9th, for example, there was nearly twice as much ablation at the crest as in the adjacent hollow. This pattern prevailed during most of the other listed periods except during the last day of record. In most cases, ablation at the crests was 20 to 40 per cent greater. On the night of the 19th to 20th, however, it averaged about the same in each portion of the feature. This equalizing was probably due to rain which occurred in the early evening of the 19th. The rain was accompanied by an abnormally warm ambient air temperature (39° to 41°F.) and was the only precipitation experienced during the period of observation. In only one other instance, between 1000 and 1800 on August 18th, was ablation exactly the same at the crest and in the hollow. This may be attributed to the fact that the time increment between readings was restricted only to midday and afternoon and was probably too short to show a significant difference. The crests, of course, receive relatively more direct insolation during the morning and late afternoon hours when the deeper portions of the cups are at least partially in shadow.

It was not the purpose of this effort to study genesis of the features or the related deterioration of the snow surface. Its objective was rather to show the nature and magnitude of differences in ablation from one portion of a suncup to another. The results amply demonstrate that special care must be exercised in emplacing stakes especially when significant comparisons are to be made between ablation in one sector of the ice field and another. The records in Table I show a fair degree of conformity between the measurements taken on the flat divide between two or more suncups. As a result of these observations, an effort has been made to emplace ablation stakes on the flattest part and intermediate portion of any undulated surface. Fortunately, it has usually not been necessary to consider this aspect until the latter half of the summer. Prior to August 1st, the névé surfaces at all elevations have not been excessivaly roughened and above the 5000-ft. elevation the névé has been characterized throughout the whole season by a smooth surface with only very shallow and ill-developed suncupping.

The size and depth of suncups are dependent on several factors. Among these are: (1) the duration of effective sunshine; (2) the angle of sun's incidence; (3) orographic conditions surrounding the névé, such as nearness and extent of rock exposures and shadow effect; (4) slope gradient; (5) slope exposure or direction of gradient; (6) micro-meteorological conditions operative at the surface during periods of suncup development; (7) vertical position of the affected surface in relation to internal firn structures such as ice strata, and (8) the presence of dust and organic matter such as algae.

For a suncup initially to form, there must be some physical inhomogeneity at the surface whereby differential ablation is introduced. Certainly, the process begins with greatest melting or evaporation at selected points where the depressions are formed. The development of suncups in this area is often cyclic. They are progressively produced and then destroyed; reproduced and re-destroyed (or at least partially deteriorated)according to the meteorological conditions affecting the névé. Prolonged periods of rain, for example, serve to reduce suncup relief and generally to level a roughened firn surface. At the end of the ablation season, in any stage of the cycle, the surface may be covered by the first persistent autumn snows. In such cases, it may show up in subsequent firn profiles as an undulated zone or band sometimes associated with a visible dirty layer if there is a sufficient concentration of wind-borne material.

Ablation measurements in the above described test were carried out largely during a degenerative hemi-cycle of suncup evolution. The development of night-time crusts in the depressions, from drainage and re-freezing of melt-water off their side slopes, could eventually retard ablation at the base of the hollows. Likewise, as already suggested, under certain conditions the relatively greater exposure of the higher crestal ridges to insolation, to driving rain and to heat conduction by air flow over the glacier could favor the greatest melting there.

These observations are neither complete nor are they necessarily typical. However, they do show in a quantitative manner that considerable local variation in ablation can occur on irregular surfaces and consequently that special care must be given to the observing technique. From the genetic point of view, it would be desirable to make a detailed study of ablation conditions on the névé during a solely generative period as well as throughout a full summer season.

4. Accumulation

Thickness of the 1949-50 snow increment was measured at several observation sites. Since the measurements were taken periodically during the ablation season, they provide supplementary information to the foregoing consideration of rate of destruction of the annual snow-pack. As already mentioned, detailed water equivalent relationships for any horizon may be obtained from the profiles of specific gravity. The average bulk density of the 1949-50 snow-pack at Sites 10A and 10B was 0.50. (See Section VIII, B3). In the higher névés, the density of accumulated snow is relatively less. For comparison, a mid-July profile obtained in 1951 at the 5900-ft. level of the upper Taku Glacier will appear in J.I.R.P. Report No.10. Note that in this figure the average bulk density (0.50) is the same as that for the corresponding July, 1950, snow-pack at the lower sites. Its range of variation, however, is smaller and its rate of linear increase with depth is likewise less. The corresponding bulk density at Camp 10A in mid-July 1949 was also approximately 0.50.

At the 10B site, no net accumulation was retained in the 1950 season due to two factors: (1) relatively low accumulation in the previous winter and spring and (2) unusually high summertime ablation related to meteorological factors not yet fully analyzed. As indicated in the report of the 1949 expedition, the winter of 1948-49 produced 23 ft. of net accumulation in the Camp 10A-10B sector (as measured in mid-June 1949). The 1950 figure was less than 15 ft. of accumulation as early as June 23rd. Even this early in the summer, it appeared that a considerable difference in annual accumulation had occurred during these two years.

The following short-term statistics concerning this year's snow-cover may be useful for future comparisons.

Table II

SUPPLEMENTARY ACCUMULATION STATISTICS RE THE 1949-50 SNOW-COVER

Date	Location	Elevation (ft.)	Exposure & Gradient	Net Retained Snow 1949-50 (in.)	(Water equiv. in.)*	Remarks
1950						
July 10	Camp 4 Névé	3900-4000	N. slope, 5°	152	76	On crevasse wall
Sept. 4	"	"	"	0	0	Ablation had proceeded into 1948-49 firn-pack by this date.
Sept. 5	"	"	"	-	-	6 in. fresh snow; on névé, end of ablation season.
July 11	Icy Pass ($1\frac{1}{2}$ miles east of Camp 10)	4300-4400	S.W. slope, 10°	128	64	On crevasse wall
July 29-30	"	"	"	-	-	Slight snowfall, 4 or 5in. at 5500-ft. level on Taku Range.
Sept. 4	"	"	"	24	12	10 in. fresh snow on névé.
July 18	Camp 10B	3575	S.E. slope, 1°	76	38	Greatest accumulation on several crevasse lips and in local depressions.
July 26-27	"	"	"	-	-	$\frac{1}{2}$ in. fresh snow at 10B and 1 in. fresh snow at Camp 10.
July 28	"	"	"	67	33.5	---
Aug. 27	"	"	"	0-12	0-6	Large sections of 1949 firn exposed.
Aug. 29	"	"	"	-	-	Trace of fresh snow in evening. (5-6 in. on "Taku B" summit).
Sept. 4	"	"	"	0	0	2 in. fresh snow, effective end ablation season.
Sept. 5	"	"	"	-	-	2.65 in. fresh snow.
June 23	Site 10A	3590	flat	103	51.5	Recorded on marker tower.
June 28	"	"	"	90	45	"
July 4	"	"	"	75	37.5	"
July 14	"	"	"	68	34	"
July 19	"	"	"	54	27	"
July 26	"	"	"	44	22	"
Aug. 15	"	"	"	15.5	7.8	"
Aug. 25	"	"	"	0	0	Ablation proceeded into 1948-49 firn-pack.
Sept. 4	10A & 10B	-	-	-	-	2 in. fresh snow.
Sept. 5	"	-	-	-	-	3 in. fresh snow.
Sept. 23	"	-	-	-	-	2 in. fresh snow.
Sept. 24	"	-	-	-	-	6 in. fresh snow.
Sept. 25	"	-	-	-	-	1 in. fresh snow.

* On basis of average bulk density of 0.50.

Diagrammatic illustration of some of the above data as well as net accumulation from several previous years is included in Figs.8a and 8b. These diagrams have been drawn from data obtained on the walls of Crevasses: No. I, II and III and of Pits A and C. Six prominent annual dirty layers could be seen in these profiles; however, the positions of three intermediate ablation levels which are shown on the sketches were not readily apparent as dirty layers. They were indicated from supplementary data which came to light in the firn stratigraphy and density profiles of Appendices D and E. These have also been corroborated by other lines of evidence discussed elsewhere in this report and agree favorably with the data from additional depth profiles taken in the general vicinity of site 10B during subsequent seasons. A tabulation of the retained firn increments since the 1940-41 budget year, as observed in 1950 in study pits and crevasses, is given in Table III. For future reference, the average bulk density of each accumulation zone and its corresponding annual gain in water equivalent is noted. The probable comparison of these eight previous years of accumulation is also shown in Fig. 7.

Table III

RETAINED INCREMENTS OF FIRN ACCUMULATIONS
(at 3600 feet elevation on the Taku Glacier)

Year	PIT C(1) (Camp 10B) 22 July, 1950 Inches Firn	Bulk Density	Water Equiv. (in.)	PIT C(2) (Camp 10B) 27 Aug., 1950 Inches Firn	Bulk Density	Water Equiv. (in.)
1949-50	-	0.50	-	-	0.54	-
1948-49	115	0.617	71	135	0.647	87.3
1947-48	49	0.657	32.2	46	0.694	31.9
1946-47	31	0.771	23.9	30	0.704	21.1
1945-46	19	0.741	14	17	0.788	13.4
1944-45	47	0.808	38	?	0.819	-
1943-44	-	0.823	-	-	-	-
1942-43	-	0.830*	-	-	-	-
1941-42	-	0.840*	-	-	-	-

Year	AVERAGE FROM CREVASSE WALLS (I, II, and III) 11 Aug.,1950 Inches Firn	Average Density**	Water Equiv. (in.)	REFERENCE NET GAIN*** WATER EQUIVALENT (in.)	(cms.)
1949-50	-	0.52	-	0	0
1948-49	127	0.63	80	80	203
1947-48	57	0.675	38.5	34	86.4
1946-47	29	0.738	21.5	22	55.9
1945-46	19	0.765	14.5	14	35.6
1944-45	46	0.813	37.4	38	96.5
1943-44	27	0.823	22.2	22	55.9
1942-43	36	0.830	29.9	30	76.2
1941-42	36	0.840	30.2	30	76.2

* Estimated,

** From average values, Crevasse III.

***Net accumulation values as of late summer 1950, from combination of most reliable data available.

5. The Névé Line

The late summer position of the semi-permanent névé line on the Taku, Twin and Lemon Creek Glaciers, for each year between 1948 and 1952, will be noted in the report of the 1951 season of this project. In 1950, the upper limit of the semi-permanent névé line on the Taku and Twin Glaciers was a short distance down-glacier from Camp 10B at 3300 to 3400 ft. above sea level. However, the seasonal névé line, represented by the position of the snow line of the previous winter's snow-cover at the end of the summer's ablation season, was even higher than the elevation of Camps 10A and 10B. This was an abnormal condition which caused an unusual number of crevasses to open up at these sites. The first persistent snow fall occurred in the Camp 10-10A-10B sector on the 23rd of September. After that date, crevasses became increasingly covered as more snow fell and the annual winter cold wave began to penetrate the glacier at progressively deeper levels. They were not completely covered, however, until late in February of the ensuing winter after the winter party had been in the field for several weeks.

From the observations to date, it appears that the end of the summer ablation season at intermediate elevations usually occurs no later than the last week of September. It has been seen to come as early as the last week of August at the 5800 to 6000-ft. level. On the past several expeditions, in order to mark the ablation surface before the first autumn snows began to fall, an insoluble lead oxide dye has been sprinkled on the surface of the upper Taku Glacier at Camps 10A and 10B and at Camp 4 on the Twin Glacier névé.

B. Physical Characteristics of the Firn

Although a complete investigation was not attempted in this season, several important aspects of the firn-cover were studied in order to supplement the records of physical characteristics taken during the previous summer. (J.I.R.P., 1952) The three main phases of this program are described below with the pertinent field data listed in Appendices D, E, and F.

1. Field Methods and Equipment Employed

Some of the equipment applied to this work was modified from that used in 1948 and 1949. The methods employed were based partly on techniques developed by the Swiss Federal Institute for Snow and Avalanche Research and also on those which have been formalized by the Associate Committee on Soil and Snow Mechanics of the National Research Council of Canada. (Klein, Pearce, and Gold, 1950)

Most of the profile equipment, as listed below, was loaned by sponsoring agencies. Some of it, however, was constructed for the project by W. F. Lossing of Seattle, Washington, on specifications drawn from experiences gained on the previous two expeditions.

6 400 to 600 cc. snow samplers (Fig. 11)
1 250 cc. soft snow sampler (N.R.C. of Canada)
1 250 cc. hard snow sampler (N.R.C. of Canada)

2	Ohaus scales, 600 grams
1	Suspending balance, 500 grams
2	Aluminum weighing pans
1	Low scale plate-type snow hardness gauge (N.R.C. of Canada)
1	High scale plate-type snow hardness gauge (N.R.C. of Canada)
50	$\frac{1}{4}$ in., 3-ft. length, wooden dowels, as markers and ablation wands
12	3/4 in. x $1\frac{1}{4}$ in. stakes (4 ft. long) for ablation measurements, etc.
3	Ruled stakes (meter stakes desirable)
1	50-ft. steel tape
1	15-meter steel tape
2	8-ft. steel tapes (inches and centimeters)
6	Waterproof notebooks and banded page clips
6	Field pencils (3H)
8	Funnel-type melt-water pans (for vertical percolation, Fig. 10)
2	Rectilinear-type melt-water pans (for horizontal flow, Fig. 10)
10	600 cc. collection containers (quart cans will suffice)
2	100 cc. glass graduates
10	Small plastic funnels (5 in. diameter)
50	Ft. of 7/16 in. diameter rubber tubing
1	50-ft. rope ladder (two 35-foot ladders with connecting shackles, desirable)
1	120 ft. 7/16 in. nylon rope
1	Pick mattock
3	D-handled coal shovels (for snow)
2	Ice axes
12	12-ounce decontaminated bottles, with caps, for water samples
12	Packets of water-soluble fluorescein dye
50	Pounds of non-soluble lead oxide dye
25	Pounds of lamp black
1	8X hand lens
1	Rectilinear scale (mm.) for grain size determination
1	Brunton compass
	Equipment for liquid water content analyses (see Appendix U)
	Requisite pollen sampling vials and accessory equipment for ecologist

2. Firn and Snow Terminology

Prior to a discussion of the firn and snow records, a few comments are included in regard to terminology. In this, recommendations for consideration in future field work are also included.

In this report, a differentiation has been made between the terms "ice band", "ice layer", "ice stratum", and "ice lamina". Previously, these have been applied more or less synonomously in referring to primary layered ice structures in a firn-pack. It is now suggested that ice lamina be used to refer to a thin sheet of ice, 3 mm. or less in thickness, which is embodied in firn or snow. (An alternative for the very thinnest observable distinct layer of ice in firn is ice lamella.) The term ice stratum is suggested as preferable to "ice layer", which has been applied by observers elsewhere to describe a thicker zone of more or less continuous ice. Where it is particularly desired to indicate a three-dimensional form, it is believed that these suggested words give a more meaningful and geometrically correct connotation than does general use of the word "band". For empirical description of the end-on exposure of an ice stratum, as seen on the wall of a pit, however, the term "ice band" is still properly usable; but only when a cross-sectional sense is implied. When referring only to the extremely thin or sheet-like three-dimensional character of a structure without appreciable thickness, a useful equivalent term for "stratum" is "layer". Thus, especially in reference to an annual sheet of summer dust in the firn, the word layer is used, often with descriptive adjectives--e.g., annual dirty layer.

When general reference is made to connote a whole series of closely-spaced and thinly-layered structures such as "ice strata", the term straticulation is sometimes used. Each unit in this case must be essentially distinct and parallel to the others. Where there is not a series of distinct ice strata and where a zone in the firn is nearly as dense as ice, or where in cross-section it exhibits a faint pattern of intermittent ice laminae (lamellae), the term icy zone is applied. This is done in order to differentiate such a zone from non-icy firn.

For general reference to a sequence of layered annual increments of firn, as observed on crevasse walls where lineation is found due to alternating differences in density and grain size, the term primary stratification is applied. A further type, for which the name secondary stratification is suggested, occurs in irregular form in cirques and at the base of cliffs. This might also be called regenerated stratification since it is caused by masses of ice, firn or snow which have avalanched from disconnected hanging glaciers or from hanging snow-fields at higher elevations. This type is found usually in avalanche fans at the base of steep névé slopes and at intermediate elevations below exposures of rock cliff which are swept by excessively heavy snow avalanches during the spring months. The primary type is characteristic of the higher and more gentle gradient névés on the Juneau Ice Field. The primary and secondary types may be confused when they co-exist in any one firn-pack. However, they are not genetically alike. For application to the two dimensional (end-on) view of a distinct homogeneous horizontal zone, use of the general term stratification band is made, - (or more specifically, primary stratification band or secondary stratification band, whichever the case may be.)

Nomenclature is also suggested for more precise description of the various cross-cutting ice features which develop within a firn-pack due to sublimation or by the direct re-freezing of downward percolating melt-water. The general descriptive heading transverse ice structures is used for these features which cut across the primary stratification. Individual components of the transverse category have been described by the writer in the 1949 Juneau Ice Field Research Project Report as "ice columns", "ice lenses" and "ice dikes". For reference to irregular forms which cannot be classified in any of the foregoing morphological categories, use of the term "ice gland" is suggested. This would be applied in a less restricted sense than by Ahlmann, who initially introduced the term to describe "irregular vertical belts" of ice in polar firn in Spitsbergen. In using this term, Ahlmann referred only to structures in the "ice column" category as they have been observed on the Juneau Ice Field. Sharp has also more recently used "ice gland" for reference only to "crudely shaped vertical column(s) of ice" in firn in the St. Elias Mountains of Canada. (If a genetic term is eventually desired for all such features, the word "gland" would appear to be inappropriate because of the physiological connotation--i.e. "a secreting group of cells.")

For the cross-cutting ice structure which forms by the infilling and freezing of water in an open fracture, the term ice vein is applied. For two-dimensional description, the term vein-ice band could be used. Because of a significant genetic similarity to the emplacement of many veins in rock, as well as for other reasons already discussed, this seems to be a more acceptable wording than use of the term "blue band". (The word vein in geological and mining literature is an accepted term for a fissure in rock filled with deposited matter.)

Reference to the term depth hoar is also made to describe those irregular, coarse-grained and sometimes cup-shaped ice crystals which often form in a basal stratum resulting from the first persistent autumn snow fall. This is a term originally applied by G. Seligman (1936, pp. 62-73). It has become universally accepted in English-speaking countries. The alternative word in German is "Schwimmschnee", a term originally suggested by W. Paulcke. The translation is desirable since this term is employed in the reports of the Federal Institute for Snow and Avalanche Research at the Weissfluhjoch, Davos, Switzerland. It is analogous to the German word "Schwimmsand" (quick-sand) and refers to the material as a whole. It is best described as an aggregate of old, coarse and granular snow of very low cohesion which is partially (or even completely) composed of depth-hoar crystals. For reference to an individual crystal within such an agglomeration, the Swiss Institute uses the word "Schwimmschnee- kristalle". In English, these are depth hoar crystals. Actually, at the Swiss Institute, an individual "Schwimmschnee" crystal is considered similar to, but not exactly the same grain shape as, the depth hoar type (Fe) which is described in the most recent International Snow Classification as the final stage in constructive metamorphosis of new snow. Depth hoar strata are of lower density than other parts of the snow-pack. This fact, together with the grain characteristics and their basal stratigraphic position in any one annual snow-pack makes them a most useful criterion for identifying late summer ablation horizons.

In discussing annual ablation levels in a firn-pack, for reasons already mentioned, the general term annual dirty layer is used for reference to horizons characterized by the typically thin layer of annual summer dust. For less explicit time reference, as in the case of periodic dirty horizons which do not represent annual increments, the unqualified term dirty layer is applied. Where there are two or more superimposed layers, the term multiple dirty layer is used, or multiple annual dirty layer if the horizon is known to represent more than a single budget year. If a solid layer of dirt is encountered which has some measure of continuous thickness (for example, volcanic ash), it could be called a dirt seam, as has been suggested to the writer by W. V. Lewis. This concentrated occurrence, however, is not usual on the Juneau Ice Field. An annual dirty layer is best differentiated in the firn-pack adjacent to metamorphic or sedimentary rock outcrops which break down easily into fine material which in turn can readily be picked up by the wind. Such a layer often lies just below a depth hoar stratum and is sometimes undulated where the surface has been significantly pitted by the influence of outcropping ice structures or by suncupping. The term dirt band is restricted to the outcrop or surface trace of such a layer as seen in truncated exposure on a sloping surface or a vertical crevasse wall. In cases where dirt is exposed cross-sectionally, not as a distinct band but rather as a hazy and often intermittent and irregular zone, the term dirty zone is used.

In the field one often observes that annual dirty layers, dirty zones and undifferentiated annual ablation horizons grade and even merge horizontally one into another. When the dirt thins out or is not otherwise present, further characteristics must be found for proper recognition of an annual horizon. These will be discussed in the report of the 1951 summer season of this Project.

In many cases, not only does the presence of much dirt help to accentuate the pattern of stratification banding but it also may become a locus of internal weakness for subsequent englacial fracturing. The structure so formed, however, is still genetically an innate part of the glacier mass involved, with the dirt remaining only as a corollary characteristic. On a descriptive basis, where a distinct fracture is characterized by the strong presence of a dirt seam or dirty zone, it would seem best to use qualifying adjectives such as "debris-entrained" or, if a minimum amount of dirt, simply to describe it as a "dirty" fracture (or "dirty thrust surface" and so forth, depending on the specific type of fracture involved).

3. Density Determinations in the Firn and Snow

Representative density profiles were obtained in the Taku Glacier firn- and snow-pack during this summer. The data are listed in Appendix E, with representative plotted values shown in Figs. 8 and 11. These may be correlated with the 1949 profiles at Camp 10A and with records subsequently obtained in 1951 and 1952 at Camp 10B. For future reference, the August density profile is considered to be most representative. The similarity of its plotted curve with that based on data obtained at this same elevation in August 1949 is of interest. The annual densification of the previous two years of retained firn is also well shown by the 1949 and 1950 comparative profiles. The increase in bulk density of the retained firn above the 1946-47 ablation surface in the intervening 12-month period was approximately 11 per cent.

The density was measured at 4- to 12-in. vertical intervals in Pits A and C. The coring equipment employed in this work is illustrated in Fig.10. Dimensional details are noted in the sketches since there are important differences in the several types of corers used which must be considered in listing and interpreting the original records. Detailed comparisons between mid-summer and late-summer records are difficult to make because the vertical profiles, although at the same elevation, were not taken at exactly the same site. A horizontal distance of even a few feet may result in local variations in accumulation causing differences in the resultant records. These differences are especially noticeable when one traces out any given firn stratum on the walls of adjacent crevasses. As ablation proceeds during any summer season, of course, the progressive exposure of deeper snow in general creates a denser surface. As an aid to interpretations, the approximate densities in grams/cm.^{3} of surface snow in representative periods during the summer are noted here.

Last week of June	0.44	Last half of August	0.52
First half of July	0.46	First week of September	0.54
Last half of July	0.48	2nd week of September	0.56
First half of August	0.50	1950 summer average	0.50

4. Stratigraphic Features

At several sites, a record of the sequence of ablation levels and intervening horizontal ice strata was obtained in pits to a depth of 29 ft. and to a depth of 40 ft. on the walls of crevasses. In Figs. 8a and 8b the sequence of ice strata at 10B is diagrammed through each firn segment since the budget year of 1943-44. Differences in the stratigraphic thickness of the individual firn increments for corresponding years in each plot are attributed to local variations through surface irregularity at the time of initial snow deposition. The pertinent stratigraphic records may be referred to in Appendix D.

An abundance of transverse ice structures of various sizes and dimensions have been described and the mechanism of their formation discussed in the 1949 report of this project. Although it was determined in 1948 that they were essentially the result of re-frozen melt-water vertically percolated along selected channels, a further study of their distribution and genesis as related to glacio-thermal regime has been carried forward. A report on these investigations is being prepared for subsequent publication. The physical nature of several of the sub-perpendicular "ice columns" and "ice lenses" is shown in the lower right-hand corner of the columnar sections in Figs. 8a and 11. They were, however, much less well-developed in the 1949-50 snow than they had been in the previous year. Only a few remnant stumps were retained below the 3800-ft. contour on the Taku and neighboring glaciers since the annual snow-cover was almost completely ablated away by the end of the summer.

Yearly variations in abundance and distribution of the transverse structures are of interest as well as some practical significance. When they occur in quantity, they have a pronounced effect on the channeling and storage of mobile water in the firn. Taken in association with horizontal ice strata, cross-cutting features increase the resistance of a firn-pack to compression and, of course, once exposed in any abundance, help to form a rough surface. This is of concern in the transport of oversnow vehicles and in travel by foot or ski. Ice columns particularly are seldom exposed in the névés above 5000 ft.; however, if formed in any quantity in the previous spring, they are usually well-exposed on the lower elevation surfaces before the middle of July. Surviving traces may occasionally be identified on the glacier surface far down valley and well into the zone of wastage. This suggests that their presence contributes to the development of rough ice surfaces below the névé line.

C. The Transmission and Storage of Unfrozen Water in Firn

To supplement the late summer melt-water studies made in 1949 at Camp 10A (J.I.R.P., 1952), a similar program was initiated in early summer, 1950, at Camp 10B. Since this site was much nearer the center of the glacier and consequently less influenced by the ground climate on adjacent nunataks, it was considered to be more representative of prevailing conditions on the upland névé. The 1949 investigations indicated that effective horizontal transmission of unfrozen water in the firn was erratic and difficult to measure except near the surface. Where it was measured, it was found to be always less than 10 per cent of the contemporaneous volume of vertical percolation. In this season, emphasis was therefore placed on measurements of the downward component.

1. Objective of Study

The primary objective was to investigate effects of the gravity transfer of freely-moving water, especially on the metamorphosis of the firn-pack into and through which it passed. A particular aspect of the study was related to the genesis of the several kinds of ice structures which have been mentioned in the previous section of this report. It was also desired to obtain further information from which an estimate could be made of the ratio between the water equivalent of gross ablation (absolute lowering of the snow surface) and that of the net ablation loss occasioned by direct percolation into crevasses and eventual runoff via subglacial drainage channels. Thirdly, it was important to the analysis of the glacier's annual budget to determine, if possible, what percentage of percolation coming from surface ablation results in a net gain in bulk density of the lower firn layers. In some glacier regions, this factor can be of considerable economic concern since it relates to the water storage capacity of a firn field which can be the source of year-around drainage from subglacial outlet streams. This type of study can, therefore be of considerable interest in hydro developments of various kinds.[3]

2. Method of Measurement

In order to record the volumetric rates of vertical percolation, a series of funnel-shaped receptacles of the form and dimensions shown in Fig. 10b were employed. For this purpose, 12-in. (30.5 cm.), circular-topped Brookins Service Station funnels were used. These have a horizontal area of 113 square in. (730 $cm.^2$). (Stock funnels for use are available from Balkrank, Inc., Cincinnati, Ohio.) The necessary modifications and attachments for this equipment were constructed by W. F. Lossing, who also made the density corers used by this expedition. Design of the percolation pans was based on similar models constructed for the 1949 field program by R. Von Heune.

[3] For example, in the Canton of Valais, the Swiss Government is at the present time pushing forward a 15-year plan to use 20 glaciers as sources of hydro-electric power. The objective is to tap a steady source of englacial water and transfer it by a system of 80 miles of tunnels into a huge dam at Cheilon. A similar project has been envisioned by Électricité de France, using water from the Mer de Glace at Chamonix.

To the lower end of each funnel, a brass fitting was attached for coupling a 4-ft. length of 7/16 in. (outside diameter) natural rubber tubing. The top of the funnel-type pan was protected by a circular, coarse-meshed brass screen to prevent snow from packing into the drainage channel. Inside the funnel, at its lower end, a small fine-mesh screen was inserted so that ice particles could not clog the outlet where the tube was attached. At the top of each funnel and above the level of the coarse screen, teeth were cut to permit the pan to be pressed into the firn for good contact with a minimum of disturbance. The funnels were gently rotated upward into the ceiling of rectilinear recesses cut horizontally 3 to 5 ft. into the walls of pits dug for this study. In each case, the drainage tube leading from the brass fitting was extended along the bottom of the recess at a sufficient angle to permit the ready flow of water. The lower end of the tube was inserted into the covered top of a collection container as shown in Fig. 10b. The recess was then filled with well-packed firn to insure that the pan would remain in position and to prevent abnormal melting of the overlying firn by any circulation of air in open spaces. In those instances where the horizontal flow component was to be measured, an elongated, shallow, box-type pan (2-3/4 x 9 x 12 in.) was used. This pan had a closed top and an open back of 25 square in. (160 $cm.^2$) cross-sectional area. A low-angled, V-shaped bottom permitted the drainage of water into an outlet nozzle at the base of the closed end. It is believed that these were probably too small to obtain truly representative readings. For future detailed records of horizontal flow, it is recommended that the dimensions of the open end be at least 3 x 15 in. (about 300 $cm.^2$).

The accessory equipment used in this work is also shown in Fig. 10b. In Figures 11 and 12 the arrangement of pans inserted in the Camp 10B firn in July and August, 1950, is shown. In these diagrams, the relationship of horizontal and transverse ice structures is also indicated as well as the specific gravity of the firn to the maximum recording depth. (For the specific gravity profile corresponding to the pan distribution shown in Fig.12 refer to Fig. 8b.)

The record of percolation rates is given in Appendix F. The value of these data is materially increased by the availability of the further records from the 1949 summer season. It is also helpful to have available a similar record and analyses obtained in 1949 and 1950 from the Arctic Institute of North America's expedition to the 5600-ft. Seward Glacier Névé in the St.Elias Mountains, to the northwest. The glaciology team on the Arctic Institute's project employed similar equipment and methods for collecting melt-water data so that their results can be readily compared with those from this project. (Leighton, 1949; Sharp, 1951, pp. 246-253).

For specific reference, the position of the percolation pans and pertinent data concerning these records obtained in the Taku Glacier firn in 1950 are tabulated in Table IV.

Table IV

LOCATION OF WATER PERCOLATION PANS IN THE TAKU GLACIER FIRN*

(Camp 10B), 1950

I. Pit A - Continuous record, July 14 to July 27.

Pan No.	Position of Top of Pan Below July 18 Surface (cms.)	Superjacent Ice Structures	Placement and Pit Walls	Remarks
I	38.1	13 cm. below a 9 mm. ice stratum	14 July at 1920, on East wall	Density at contact, 0.48
II	78.7	Firn above, with ice lenses	15 July at 1000, on North wall	Density at contact, 0.51
III	165.1	Firn above	15 July at 1800 on East wall	Density at contact, 0.50
IV	254.0	Top of pan just below 37 mm. ice stratum and in icy zone	16 July at 1400, on East wall	Density at contact, 0.54
V	243.8	Top of pan just above 37 mm. ice stratum	17 July at 1630 on South wall	Density at contact, 0.54
VI	327.7	Firn above	17 July at 1730 on South wall	Ice stratum above pan No. IV lensed out into firn above pans VI and VII and reformed again farther west
VI A	Note: at 1030 on July 21, pan No. VI was moved 76 cm. to left but at same level. New location was under ice stratum at pan No. IV but 74 cm. below this stratum.			
VII	327.7	Directly under a sub-vertical ice column, 20 cm. in diameter and 76 cm. high.	18 July at 2115 on South wall	---

*See Figs. 11 and 12.

II. Pit C - Intermittent record, July 29 to August 25.

Pan No.	Position of Top of Pan Below July 30 Surface** (cms.)	Superjacent Ice Structures	Placement and Pit Walls	Remarks
VIII	40.6	In firn	29 July at 1930 on South wall	Density at contact, 0.45
VIII A	114.3	In 25 mm. ice stratum of coarse-grained crystals	Re-placed 18 Aug. at 1830 on South wall; 66 cm. below Aug. 18 surface	Density at contact, 0.91
IX	182.9	In firn	29 July at 1930 on West wall	Density at contact, 0.59
X	304.8	In firn, just under coarse-grained 25 mm. ice lens and 13 cm. below a 50 mm. coarse-grained ice lens	30 July at 1300 on East wall	Density at contact, 0.62 Both ice lenses fairly well covered area over pan
X H	304.8	In firn	25 Aug. at 1830 on South wall	Density at contact, 0.63 (horizontal component pan)
XI	482.6	In firn, 13 cm. below a 25 mm. ice stratum	30 July at 1510 on West wall	Density at contact, 0.67
XII	594.4	In firn, just below a 25-50 mm. ice stratum	30 July at 1730 on East wall	Density at contact, 0.80

**For depth below August 29 surface, see Appendix F-II.

Detailed interpretation of the records is not attempted in this report since the analyses are being prepared for later presentation. It should be noted, however, that the position of Pan No. VI in Pit A was shifted, after four days in its initial position, 76 cm. to the left (to position VIA Fig. 11), so that it rested 74 cm. beneath the prominent ice stratum at the level of the top of Pan No. IV. It is of further importance to the analyses that Pan No. VII rested directly beneath a 20-cm. diameter ice column. Pan No. VIII was moved from its inital position in the surface snow of July 29th to a new position 66 cm. below. Its top was pressed into the base of a coarsely crystalline ice stratum (Pan No. VIIIA). The position of a horizontal component pan (X-H) is noted in Fig. 12. Supplementary notes on pertinent firn and meteorological conditions at the observation site during the period of record in Pit A are provided in Appendix G. The periodic records of vertical percolation at each site, in terms of cubic centimeters of water over a given period of time, may be referred to in Appendices F-I and F-II.

In the final analyses, the three-hourly synoptic meteorological records for 10B during the observation period should be reviewed. Supplementary to these are the ambient surface temperature records in the katabatic air layer up to 36 ft. above the névé. (See Section IX-B) The relationships are best illustrated by histogram plotting of the flow data for each day of record. A preliminary study of the nature of the graphed results shows that there was a significant volumetric increase in water percolation at times of heavy and continuous precipitation as well as on clear days when melt-water generation was above normal.

3. Conditions of Mobile and Static Water

When analyzing the data in Appendix F, it must be kept in mind that the measured flow rates represent, in part, surface snow melt-water and, in part, rain water which fell at the observation site. The differentiation may be partially assessed by the review of contemporaneous meteorological conditions. A preliminary study of the percolation records indicates that there was a very effective downward migration of water which partially accounted for variations in position of the water table as observed in the bottom of crevasses. (See Table V) The daily peak of downward percolation at the level of the bottom recording pans was usually several hours later than in those emplaced near the surface. The significance of this time lag and its comparison with conditions observed in other seasons of record is being discussed in the final report.

As in 1949, the flow was found to be predominantly vertical. There was some obstruction to the downward transfer imposed by the presence of horizontal ice strata. The 37 mm. ice stratum above Pan No. IV, for example, and the 25 mm. ice stratum above Pan No. VIIIA proved to be fairly effective barriers to the downward percolation, although in each case, some flow was recorded below them. This was probably due to the fact that these strata consisted of fairly coarse ice grains with intra-crystalline sutures through which some of the water could pass. Horizontal flow above such horizons was not detected, but this may have been due to an ineffective measuring technique rather than to an actual dearth of freely moving water.

Eventually, the impounded water did pass to lower levels, some of it probably also moving laterally to places where the ice strata thinned out into firn. The superjacent ice stratum over Pan No. IV lensed out to the westward so that only firn existed above Pans Nos. V and VI... This may account for the similarity of flow readings in Pans Nos. V and VI during and shortly after periods of prolonged and heavy rainfall. (See Fig. 11 and Fig. 16)

It is noted that if surface firn temperature conditions under atmospheric changes had suddenly dropped below freezing, the water which filled interstices in the firn overlying the impermeable ice strata would have frozen in place. Thus, the ice strata involved would have become materially thickened. This condition undoubtedly occurs during the late spring. In the period of observation, however, there was no such apparent local increase in density except that which could normally be explained by the continual process of compaction. From July to September, the firn conditions were isothermal so this situation was to be expected.

There was a remarkable consistency in the ratio of free water at several levels in the firn even though in the recording period considerable variations were noted in the volume transfer of water. The problem would seem to be one involving the steady state of an open system which is independent of time. (See Strahler, 1952) In order to test the ratio of unfrozen water retained in interstitial spaces in the 1949-50 firn-pack,. the following efforts were made. The non-calorimetric method, referred to in the report of the 1949 field season, was employed. It is believed that the use of a wider-mouthed thermos flask provided some improvement and a reduction in instrumental error. For comparison, a standard calorimetric technique was also used. Brief details of each method and bibliographic references for future use are given in Appendix U.[4]

The non-calorimetric method requires further experimental laboratory testing before its basic formula can be reliably applied for refined measurements. However, the average results obtained from a number of determinations compare favorably with those by a calorimetric technique. Samples of firn were tested only at Camp 10B. The ratio of unfrozen water in surface firn and in a firn stratum at depths of 12 and 24 in. is indicated below for several days of record.

[4]The practical calorimetric technique applied by the Cooperative Snow Investigations of the U. S. Weather Bureau and the Army Corps of Engineers is also mentioned in the appendix for possible future use of this project. This method, based on techniques employed by the U. S. Weather Bureau and the Pennsylvania Water and Power Company, is described in a mimeographed Operation manual of the Snow, Ice and Permafrost Research Establishment. The instructions have been drawn up for personnel with limited experience. It is cautioned, however, that in all these methods the best results can only be obtained by persons who establish a definite and routine-like operational technique and who acquire a more than casual experience with the procedure.

Free-Water Ratio Test in 10B Firn, 1950

Non-Calorimetric Method

Date and Hour	At Surface,%	Sp.Gr.	At 12 in. Depth, %	Sp.Gr.	At 24 in. Depth, %	Sp.Gr.
26 July, 1600	(1) 33	0.47	(1) 21	0.47	--	--
	(2) 28.5	0.47	(2) 20.5	0.47	--	--
29 July, 1500	--	--	(1) 19*	0.46	--	--
	--	--	(2) 22*	0.46	--	--
29 July, 1900	(1) 20	0.48	(1) 25	0.46	(1) 22	0.50
	(2) 22	0.48	(2) 20	0.46	(2) 20	0.50
3 Sept., 1130	(1) 35	0.55	--	--	--	--
	(2) 37	0.55	(after heavy rain)			

It is of interest that the variations noted above are not great. During the period of observation on July 29th, there was a completely overcast sky, a below-average ablation condition at the névé surface and heavy rainfall (0.4 in. between 1300 and 1900). In this case, the effect, if any on the measured free-water percentages by the downward flushing of rain water is not clear. A similar ratio, however, was indicated for the 12 in. depth on July 26th, a day on which percolation water was dominantly the result of ablation rather than rainfall. The surface firn on this date had a slightly higher water content. On September 3rd, the free-water percentage was slightly higher after another period of heavy rainfall. In this case, somewhat denser firn was involved. Surface tension might be expected to be a more effective agent in retaining water in the interstices of denser firn due to the more closely packed nature of the crystal aggregate.

In the field test, a fair agreement was found between the results obtained with the calorimetric and non-calorimetric methods. It is probable that the variations from the mean of these results are largely within instrumental and personal errors. These data are only of the most brief nature; however, from them we have an indication of the amount of free-water in the surface of typical summer firn. Free-water measurements taken at corresponding levels in the annual firn-pack in August, 1949, show an upper limit of 36 per cent of unfrozen water as compared to 37 per cent in 1950. Even though the methods used in these determinations may not give absolute accuracy, it is of interest that the maximum water content measured in these two seasons is in such close agreement.

*The corresponding ratios by the National Research Council of Canada's recommended field calorimetric method were (1) 15 per cent and (2) 20 per cent at this level.

The ratio of unfrozen water retained in air bubbles in deep glacier ice on the Taku Glacier was also studied. The results will be discussed by Bader and Wasserburg in their final report on the crystal fabric investigation of core samples obtained in the drill holes at Camp 10B. For a review of the nature and significance of this type of research, refer to Bader, (1950).

4. Variations in the Firn Water Table

On each summer expedition since 1948, water has been observed impounded in the bottom of crevasses at various elevations from the termini to the higher névés of the ice field. For the most part, these have represented local "perched" water tables. On the broad and relatively flat upland névés, however, a fair conformity of water level has been observed between crevasses. This has probably been effected through zones of saturated or semi-saturated firn and by connected alcoves and joined fractures which are subsidiary to the crevasse pattern.

Due to local differences in the depth and form of crevasses in any one system, correlation of short term variation in positions of individual water levels is not always possible. An important fact, however, is that considerable variations in water level do occur in the major crevasses throughout the ablation season. The observations made in Crevasse I and in a bore hole at Camp 10B illustrate this point.

These measurements are considered to be accurate within one foot. The statistics show that the water level varied between a depth of 50 and 74 ft. below the mid-summer névé. The fair agreement with the level noted in the bore hole. 25 ft. away, on August 3rd to 9th and again on August 28th shows that in this case, at least, the crevasse water level also approximated the position of the water table in nearby firn.

Generally, the water table would rise to its observed upper limit in this and adjoining crevasses after prolonged periods of rain fall. After extended periods of clear weather and sunshine, in spite of heavy surface ablation, the water table would gradually drop to the lower recorded limit. As noted in Table V, on several occasions there was more rapid drainage which nearly emptied the crevasse of all water. This phenomenon was related to other factors and does not obscure the fact that at this location on the Taku Névé, rain water was much more effective than ablation melt in raising the glacier's local firn water table to its maximum upper level.

Table V

OBSERVED VARIATIONS IN THE LOCAL WATER TABLE, CAMP 10B FIRN

Date-1950	Depth in Crevasse I Below Aug. 1 Névé Surface (in ft.)	Remarks
July 28	57	Depth recorded below July 28 surface
July 29	58	
July 30	59	
Aug. 1	59	
Aug. 3 (a.m.)	60	
Aug. 3 (p.m.)	66 (66)*	Water level suddenly lowered
Aug. 4	73	Sudden drainage into extension of crevasse system
Aug. 5	(74)*	Very wet firn in core samples at depths of 80 to 116 ft.
Aug. 9	67 (65)*	
Aug. 11	70 +	Sudden drainage
Aug. 12	73	
Aug. 15	65	
Aug. 18 (p.m.)	70 +	Sudden drainage
Aug. 23	74	On 18th day of continuous clear weather with no rain
Aug. 26 (a.m.)	55	After 3 days of continuous rain
Aug. 28 (p.m.)	50 (50)*	After 3 more days of very heavy rain
Aug. 30 (a.m.)	59	Lowered 4 ft. in 3 hours
Aug. 30 (p.m.)	70+	Sudden drainage

*Figure in parenthesis represents observed water level in bore hole 25 ft. from crevasse. This depth was measured below wooden drill platform, which also rested at level of the August 1st névé.

D. The Surface Form of Truncated Englacial Structures

The following notes are presented to supplement the comments on glacier "banding" and related subjects in previous reports and to indicate the nature of further investigations currently underway.

1. A Terminology for Truncated Structures Observed on the Surface of Glaciers

In glaciological literature, a number of diverse and unrelated terms such as "Forbes dirt bands", "chevrons" and so forth have been used to refer to the arcuate and banded surface expression of certain englacial structures which form below ice falls and which are so often associated with a wavy longitudinal surface profile. In this latter case, it is usually possible to trace the inlaid structures back up-glacier to a source in the periodic stratification of firn. Such stratified "sedimentary" structures often embody complimentary layers of organic and inorganic aeolian material and, on steep slopes, even debris from rock falls and snow avalanches off nearby cliffs. The whole mass eventually passes down-glacier into the zone of wastage, with the relict layering, often accentuated by accumulations of summer dirt, becoming exposed on the ablated low-level slopes in truncated exposure. They may form a marked system of curved bands. On the basis of their original state, these may be considered as modified examples of the primary or secondary stratification bands which have already been discussed. For this subsequently deformed type, the term arched stratification band was suggested in the report of the 1949 expedition of this project.

For the similar curved features which only form below ice falls, the term arched bands was suggested. The use of the word "band" in this context only referred to the two-dimensional surface manifestation of what was actually an englacial structure. This suggestion was made in an effort to provide a descriptive term which did not have a genetic connotation. To clarify the observable surface geometry of these bands, as seen on different glaciers in the area, three terms for subsidiary types are mentioned: (1) rounded-arches; (2) pointed-arches; and (3) distorted-arches. These terms are slightly modified from those initially suggested in 1949 as empirical variations which may occasionally be useful to show the related pertinent differences in topography of the bed rock channel along which the particular glacier flows. In this context, the term ogive is not employed in this general terminology because out of the two dozen or more "arched band" glaciers which the writer has observed on the Juneau Ice Field during the past few years, only three have been seen to exhibit bands which resemble true ogives. It is therefore believed that the term "ogive", which has been more generally applied by other observers, should be restricted to special cases where individual bands in the pointed arch category are of this specific geometric form.

It is also recommended that the word "dirt" be avoided except in qualifying reference to specify distinctly dirty bands on any one glacier. The reason for this is that the arched appearance may be produced by purely physical differences in the ice, such as alternations of texture or structure. Thus, it would seem that the term "dirt band" should not be used in this context. In glacier ice, as already noted in the discussion of firn features, the presence of dirt in primary stratification layers may modify the shear strength of a particular zone and provide a more amenable locus to fracture. Also, as previously noted, where dirt is very prominently seen in association with such structures, it should be mentioned. Thus, in solid glacier ice the terms "dirty layer", "debris-laden thrust surface" and so forth would be used.

For the description of fractures not characterized by dirt, the general terms shear-induced surfaces and thrust surfaces (single and multiple) are employed for three-dimensional reference; and shear bands and thrust bands (single only) for cross-sectional or two-dimensional description. Use of the word thrust is usually restricted to those cases where the fractures are large, relatively infrequent, and at a low angle to the horizontal. Sometimes along overthrust surfaces in ice, one observes a certain amount of mechanical granulation and recrystallization; however, this is a most common characteristic of those local zones of finely-spaced fractures which are associated with shearing. In cases where such multiple fracturing has occurred, the following general terms are used for two-dimensional reference: (1) ribboned tectonic ice bands (when close-spaced and foliated) and (2) imbricate thrust (and shear) bands (in cases where an overlapping or a shingled character occurs at the outcrop.)

An outline of the suggested terminology for field use is listed below. The classification has been divided into two categories: (1) for reference to the two-dimensional surface appearance of englacial structures and (2) for use where the englacial or three-dimensional aspect is considered. These suggestions have been introduced in the hopes that they may aid in developing a more adequate and meaningful terminology and perhaps one which is not unduly controversial. (Some of the terms in Part I of this outline have already been reviewed in Section VIII-B2. Others, in Part II, are discussed in the next section of this report.

Suggested Field Nomenclature for Glacier Structures

I. For Three-dimensional Reference to Englacial Structures

A. Stratification Features
- (a) Primary Stratification (originates in firn)
- (b) Secondary or regenerated stratification (originates in firn)
- (c) Dirty layer (annual or periodic)
- (d) Multiple dirty layer (representing two or more superimposed dirty layers)
- (e) Dirty zone (multiple, annual, or periodic)
- (f) Dirt seam*
- (g) Ice stratum (thick, greater than 3 mm.)
- (h) Ice lamina (thin, less than 3 mm.)

*This term is employed when the "layer" is composed entirely of dirt and not of mixed dirt and firn (or ice). For example, a solid "layer" of volcanic ash, such as commonly occurs on the Vatnajökull in Iceland and in certain Andean glaciers, would properly be termed a dirt seam. Near the termini of glaciers, dirt debris are also often associated with thrust surfaces. In this special case, it may be introduced by the overthrust mechanism instead of primary stratification.

B. Transverse Ice Structures (primarily in firn)

(a) Ice column
(b) Ice lens
(c) Ice dike
(d) Ice gland (non-descript form)

C. Secondary Fracture Structures (primarily in ice)

(a) Ice vein (infilled)
(b) Shear-induced surface (or "shear" surfaces, single and multiple)**
(c) Thrust surface (single and multiple)**

II. For Reference to the Surface (two-dimensional) Manifestation of Internal Structures

A. Ice Bands***
(a) Ice band (ice stratum band, in firn)
(b) Vein-ice band (infilled)
(c) Tectonic ice bands
1. Single
i. Shear band**
ii. Thrust band**

2. Multiple
i. Ribboned tectonic ice bands (outcrop of close-foliate series of shear-induced surfaces)
ii. Imbricate shear bands (if shingled)
iii. Imbricate thrust bands (if shingled)

B. Stratification Bands
(a) Primary stratification band**
(b) Secondary (or regenerated) stratification band**

C. Arched Bands**

On the descriptive basis, these are considered as composed of three empirical types: "rounded arches";"pointed arches" and "distorted arches". A genetic basis of nomenclature for this class should await the satisfactory resolution of their three-dimensional aspect.

**Where characterized by the presence of dirt or the strong development of dirty zones, properly qualifying or additionally descriptive adjectives may be used; e.g. "dirty", "dust-laden","debris-entrained".

***The equivalent three-dimensional reference is preferred except in special cases where the significant characteristic is embodied only in the surface expression (such as category II, A, (c),2).

2. Arched Stratification Bands and Related Overthrusts near Camp 10

At Station 10C (Fig.3), one mile due north of Camp 10, a noteworthy exposure of primary stratification is to be seen in a tributary glacier lobe of the Taku névé. The sequence contains a series of 50 or more annual firn increments intercalated with dirty layers which give a strongly banded character to the surface. The glacier at this site flows through a notch in the ridge end at the northwest side of "Taku B". Because it has a southern exposure and is rimmed on each margin by bare rock outcrops, the ice surface usually loses its névé cover in the latter half of summer. Englacial structures thus become exposed and provide a fine opportunity to observe layered features which have largely retained their original character. The glacier spills through a narrow bedrock channel at a fairly steep angle so that its primary structure is bent downward in a series of arcuate and concentric segments. The stratigraphic attitude of these segments is tabulated in Appendix H, along with other data. The surface pattern here is a good example of arched stratification banding. It is illustrated by a schematic plan view in Fig. 9, in which the superimposed crevasse pattern is also shown.

The presence of several thrust bands in the sequence has been detected. Two dominant ones are noted in the figure. Some were evidenced by a marked scarp in places where no annual dirty layers occurred. In the profile data listed in Appendix H, however, the thrust surfaces are shown usually to be contiguous with dirty laters which at the points of transect probably represent planes of weakness along which the fractures occurred. (See below.) An ice axe shaft could be inserted with ease along thrust surfaces at points x, y, and z (in figure), for a distance of 30 in. or more. This was not possible at the trace of the non-sheared primary stratification dirty layers.

Measurements were obtained of differential movement above and below one overthrust surface at a point 60 ft. west of point z on the eastern transect. To accomplish this, a set of narrow wooden dowels was inserted into drill holes bored 28 in. into the ice immediately above and below the thrust horizon. Successive measurements between two opposite marks on these stakes over one 21-hour period (August 20-21) indicated a relative throw of 16 mm., with the upper mass over-thrusting the lower at an angle of 32 degrees from the horizontal.

On the edges of this ice tongue, hundreds of closely spaced parallel shear bands, appearing in a foliate pattern, could be seen. Their surface trend was more or less parallel to the primary stratigraphic banding on the glacier margin. Each shear band was 1/4 to 1 in. wide and was characterized by granulated and re-crystallized ice. In some, there was a distinct line of fracture in the center of the granulated zone. Such a system of ribboned tectonic ice bands was likewise exposed on the lower edges of the lobe, Here the strike and dip of each fracture was also parallel to the general attitude of the nearest dirty layer.

In a few instances some of the larger and more distinct fractures were observed to cross-cut one another and even to transect the stratification sequence for distances up to 15 ft. This was incontestable evidence that these were individual fractures and not merely phenomena due to differential ablation along a dirty band. In several places what appeared to be an imbricate sequence of thrust segments was observed over-lapping one another at one- to two-ft. intervals. All of the shear surfaces associated with the tectonic banding dipped more steeply towards the center at the edges of the lobe. The average dip at the intermediate elevation on each side was respectively 40° to 50° N.W. (east rim) and 40° N.E. (west rim), with a 17° to 20° N. dip occurring at the center of the basal slope. At the top of the outlet lobe, the northerly dip of stratification gradually decreased nearly to horizontal, at which attitude there was no visible evidence of related overthrusting. Throughout the sheared zone, a number of cross-cutting coarsely crystalline ice veins could be seen. These were the result of re-frozen melt-water which had filled former open fractures.

Below Station 10C in four banded increments separated by five dirty layers along a slope distance of 24 ft., a continuous sampling of the ice was made for pollen content. The pollen collections and grain count and species identifications were made by the field party's ecologist, C. J. Heusser, who is preparing an ecological report on his findings. Briefly it may be said that as in the young firn at site 10B, high pollen counts were closely related to dirty layers in the section analyzed. One of these also appeared to be a thrust surface. For example, a heavy concentration of willow pollen (Salix sp.) was observed in or just above a zone of re-crystallized ice consisting of hugh crystals, some with dimensions up to 12 in. This may also be related to an old ablation surface (or a multiple annual layer).

At the lower end of each transect noted in Fig. 9 there is a zone of relict basal ice which was exposed to view by the abnormal down-glacier shift in local firn limit at the base of the slope. Here there may have been some tectonic overriding of younger ice on the older residual block along a low-angled fault plane. If true, the overthrust surface parallels a very old ablation horizon. Below the contact, an excessive quantity of debris, including several large erratic boulders, has been exposed and concentrated on the relict ice slope by ablation.

E. Glacier Movement Surveys

The following brief notes have been prepared from information kindly provided by C. R. Wilson, the surveyor in charge of this phase of the program. All fixed triangulation stations and base lines used in this work are noted in Fig. 13 and described in Appendix T.

1. Transverse Surface Profiles

The movement stakes employed in these surveys consisted of one-meter rods, with a $1\frac{1}{2}$ in. square cross-section held upright by metal braces attached to prefabricated flat-based stands. The stakes were flagged with blue, black or red cloth for better visibility.

On July 8th, ten stakes were set out on the glacier for Profile IV (Fig. 3). This profile extended along a line 29 degrees to the north of the azimuth between Stations 19 and 21 and roughly coincided with a seismic depth profile from the previous summer. (Movement Profile IV was approximately 12 degrees north of Seismic Profile 4.) The stakes were positioned at approximately 1100-ft. intervals. A layer of insoluble lead oxide was thinly spread about the base of the stakes farthest from Station 19 in the hopes that this would facilitate their relocation. The dye proved to be of little help and, in fact, had a deleterious effect since it caused a large ablation crater to form which made it awkward to re-occupy the station accurately at the end of summer.

On July 13, six stakes on movement Profile III were positioned. The stakes had been air-dropped at the "Columbia"Glacier moraine a few weeks before in order to save back-packing them down-glacier from Camp 10. They were placed 1500 to 2000 ft. apart on a profile extending from the base of Station 31 southward along Seismic Profile 3 (Fig. 3). To aid in this work, the 1949 cache at Camp 11A (now designated as Camp 11) was opened and the camp site re-occupied. On July 14th, the stakes of Movement Profile II were emplaced. This profile was coincident with Seismic Profile 2 and extended across the Taku Glacier and at a right angle to the valley-wall beginning at the south end of the "Columbia" Glacier moraine. Due to bad weather, it was not until July 22nd that Station 18 could be re-occupied to fix these two movement profiles in relation to the local control mapping network.

On August 22nd, the positions of the stakes on Profile IV were re-surveyed. All stakes were recovered with the exception of No. 10 which had fallen into a crevasse. Most of them were still standing. Unfortunately, several of those which had been surrounded by the insoluble dye had sunk into abnormally large ablation craters and had tipped over. Before the re-survey, they were placed upright in their original positions in respect to the dye marks. By this date, crevassing on the glacier had increased to such an extent that the surveyor could proceed only with great caution and by being roped.

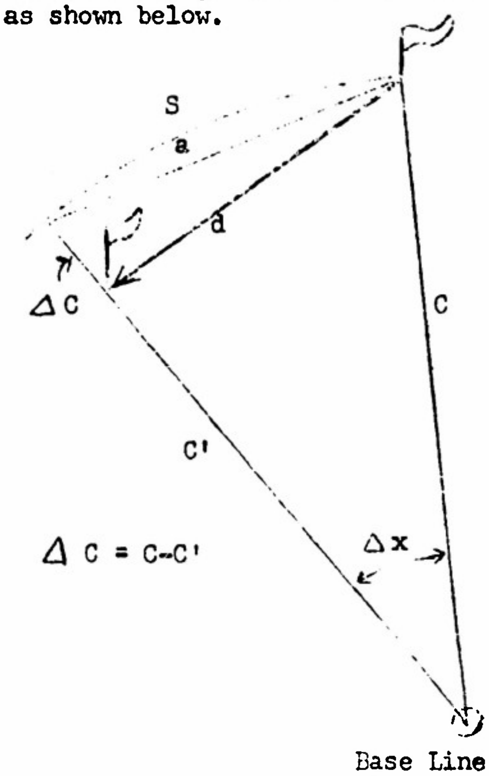
On September 2nd, the six stakes of Profile III were re-occupied. All stakes were intact and standing in spite of the increased crevassing. On the evening of September 3rd, Station 18 was re-occupied. From this station, all stakes of Profile III could be seen, but none of Profile II was visible even with the aid of the theodolite telescope. The very rough and crevassed nature of the glacier surface along this traverse precluded their view. The party attempted to re-locate the stakes by travelling out on the glacier. Travel was possible only by cutting steps. On this date, severe weather and fresh snowfall began which forced the surveyors to return to Camp 10. Because of other commitments, it was not possible for them to return later in the season to complete the record on movement Profile II.

2. Triangulation Method and Calculations

The base line used for positioning stakes on Profile IV was delineated by Stations 19 and 22. The base line for Profile III extended between Stations 18 and 22. To solve the triangles, each individual stake was occupied and the angle measured between the rays to two stations. Station 19 was used to obtain the other angle for Profile IV and Station 22 for ProfileIII. This procedure was repeated at the end of the season so that two comparative triangles were obtained for each stake.

All angles were measured with a Wild Theodolite to an accuracy of a few seconds of arc. The base lines were taken from the project's basic triangulation mapping network.

Each profile line was established approximately perpendicular to the direction of glacier surface flow in order to make it more convenient to set up an expression for the increment of distance moved. This was done so that the term which contributes the most to the accuracy of the surveys is the one involving two functions: (1) angular change in position of the stake as seen from the station and (2) the distance of the stake from the station. Other terms in the expression produce second order effects which tend to correct for the departure from the perpendicular and for any minor errors primarily introduced by the fact that the distance moved is not the true arc of a circle. This method saved much time especially on Profile IV where the second order terms could be neglected. A derivation of the expression for the distance any given stake moved over the time involved is provided by Mr.Wilson as shown below.



$$S = C\,\Delta x$$

$$a = 2C \sin \frac{\Delta x}{2}$$

$$d^2 = a^2 + \Delta C^2 - 2a\,\Delta C \cos\left(90 - \frac{\Delta x}{2}\right)$$

$$d^2 = \Delta C^2 + 4C^2 \sin^2 \frac{\Delta x}{2} - 4C\,\Delta C \sin \frac{\Delta x}{2} \cos\left(90 - \frac{\Delta x}{2}\right)$$

for Δx small, $\sin \Delta x = \Delta x$

$$d^2 = C^2\,\Delta x^2 + \Delta C^2 - 2C\,\Delta C\,\Delta x \cos\left(90 \mp \frac{\Delta x}{2}\right)$$

The sides C and C' were calculated from the sine law using the data obtained in the surveys from each of the referenced base line stations.

The elevation and direction of each stake was calculated in the manner indicated on the calculation sheets filed at the American Geographical Society. A tabulation of these data is given in Table VI and a graphical presentation in Fig. 13.

Table VI

TAKU GLACIER SURFACE MOVEMENT ON TWO PROFILES, 1950
(Positioned on Seismic Profiles 3 and 4)

(a) Profile IV

Stake No.	Map Distance* from Station 19 (feet)	Elevation above m.s.l. (feet)	Horizontal Velocity (feet/day)	Direction of True Movement
1	2543	3721	1.12	151
2	4193	3720	1.17	136
3	5564	3720	1.82	150
4	6468	3731	2.08	124
5	7290	3721	2.76	105.5
6	8593	3737	4.15	97
7	9976	3765	2.0	133
8	11338	3763	2.04	127
9	12630	3765	1.77	126
10	-----	----	----	---

(b) Profile III

Stake No.	Distance from Station 18	Elevation above m.s.l. (feet)	Horizontal Velocity (feet/day)	Direction of True Movement
11 (1)	25887	3417	1.55	143
12 (2)	24579	3424	0.23	189
13 (3)	23195	3429	1.66	155.5
14 (4)	21768	3429	1.21	171
15 (5)	19668	3409	1.53	163.3
16 (6)	16929	3384	0.94	147

*On line of sight to Station 60 ("So.Taku Tower")

3. Surface Gradients

With the theodolite, gradient measurements were taken on movement stakes in Profile IV. These are listed below in minutes of arc of depression taken from a horizontal line in a southeasterly down-glacier direction.

Stake No.	1	2	3	4	5	6	7	8	9
Depression Angle (Mins.)	14.5	14.5	27.5	50.5	33.6	26.2	14.5	18.3	38.6

The average down-glacier slope gradient of the névé surface at the site of the englacial aluminum pipe was also determined to be approximately 1 degree of depression angle.

4. Movement Measurements at the Taku Glacier Terminus

An additional effort was made to determine the order of magnitude of horizontal movement on the lower Taku Glacier. This was desired also for comparison with the surface flow records obtained in 1949 at the 1300 and 1500-ft. contours in the vicinity of Camp 12. For this purpose, a position on the glacier was triangulated 3/8 mile back from the tidal center of the terminus and at an elevation of 300 ft. above sea level (For location see Fig.3). Horizontal angles were obtained by transit sights to some of the 1937 U. S. Coast and Geodetic Survey stations in Taku Inlet. The stations used were Station OOZE; the summit of a small rock island just off-shore from Station SNO; Station JOYCE; Station NORRIS, and several other prominent identification markers in the inner part of the inlet. The record covered a period of 27 days from September 7th to October 4th, 1950. A resolution of these data shows a total movement, in a southeasterly direction, of approximately 13 ft. during the period of observation, or an average of 0.5 ft. per day. It is cautioned that this figure is only representative of the west central part of the terminus in this one summer. The point of observation was directly behind an overriding portion of the glacier obstructed by an inert mass of black ice in direct contact with the most prominent part of the 1950 push moraine. The easternmost third of the terminus was observed to be washed by the tides and to be much more broken and active. It also gave every appearance of moving forward at a considerably more rapid rate than the central and western sectors of the front.

5. Recommendations

Mr. Wilson has pointed out that for the surveyor the greatest technical difficulty in field work involving surface velocity measurements on a glacier is introduced by the topography of the bedrock margins where the surveying instrument must be set up. Particularly in this highland area the nunataks (which offer the only foundations for reference stations) are often very inconveniently situated so that very long sights become necessary. Excessive lengths of sighting rays, of course, decrease the accuracy of measurement. Mr. Wilson used the method of solving vertical as well as horizontal triangles because with measured gradients it can give the three-dimensional movement (distance and direction) of a stake. He states that the angles measured with the instrument set up on snow are usually inferior to those measured while on ice or rock. In this connection, it should be mentioned also that because of low-angled firn creep (as discussed in section VIII-G,c), it is to be expected that the records of movement stakes established on bare ice will be more representative of the glacier's mass movement than will be those records taken at the surface of a substantial thickness of firn.

In future work it is recommended that two bedrock stations be occupied instead of one on bedrock and another at the stake. The resulting measurements should be more precise and the possible inability to re-occupy the stakes because of the glacier's crevassing would not hinder the program as it did in the case of Profile II in this season.

One bedrock base line upon which two or three stations can be established gives the most accurate results (refer to the 1949 movement work on the lower Taku Glacier, Fig. 35, J.I.R.P. Report No. 6). The distance between the bedrock stations can easily be determined by the use of stadia or by triangulation. For glacier volume transfer records, three stakes with one at the center and the other two equally separated transversely across each half of the glacier should be sufficient. For detailed differential flow studies on a short-term basis, it is recommended that stakes be placed about 1000 ft. apart to form a cross-glacier profile.

F. Mechanical Core Drilling on the Taku Glacier

The rotary drill program carried forward in this season represents one of the first attempts to obtain undisturbed cores of firn and solid ice from depth in a temperate glacier. Through this effort, in which boring was accomplished to nearly 300 ft. in the accumulation region of the Taku Glacier, a number of subsidiary englacial investigations were made possible. Such a three dimensional approach to the study of existing glaciers represents a relatively new and specialized form of glaciological research, the progress of which will largely depend on the further application and improvement of boring methods. Aspects of the mechanical technique employed, a presentation of the scientific records which were obtained, and a preliminary discussion of the results achieved in this program are given in the following pages. Since it is expected that further observations will be made on the alignment and temperature measurements within the holes which were drilled, amplification of the appended records is anticipated in the future.

1. Review of Rotary Boring Efforts in Other Glaciers

In appreciation of the value of other such investigations which have been conducted, primarily in polar areas, by European glaciological teams the following preliminary notes are presented on the background of this technique as applied to glacier research in other areas.

a. Early Efforts

As long ago as 1842, attempts were made in the Alps mechanically to bore into glaciers to determine their thickness. It was not until 1901, however, that any great depth was reached. In that year, the German glaciologists, Blümcke and Hess, successfully used a mechanical drill rig which could drill at a rate of 3 to 4 m. per hour. By this means, considerable lengths of their boring rods could be left in several holes drilled into the Hintereisferner, - one of them to a depth of 300 m. Over the following years, this metal pipe became increasingly exposed by ablation at the glacier's surface. No quantitative inclination measurements could be made at depth. However, in the course of time, the pipe's upper end became more and more tilted down-valley. Due to the relatively more rapid surface motion of the glacier, the pipe eventually became rotated into a more or less horizontal position (Blümcke and Hess, 1909, 1910, 1923/24).

Small mechanical rotating drill rigs have been employed in glacier ice by other investigators since that time. Most of these have been of the hand-operated type, such as those used by Philipp (1920, see especially p.537) and by Ahlmann (1935b) in the period between 1910 and 1935.

Shortly before World War II, M. Ract-Madoux, in France, perfected another type of hand-operated ice auger using a salt-water injection in order to prevent jamming of the drill hole by pieces of ice chipped off during the operation. The rig was used to drill successfully at an average rate of a little more than one meter per hour (Nizery,1951, p. 66). If it had been powered by a motor, faster drilling rates undoubtedly could have been achieved.

b. Mechanical Drilling on the Mer de Glace

It was not until 1950 that any serious attempts were made to apply engine power to the mechanical drilling of glacier ice. Contemporaneous with the Taku Glacier boring program, Ract-Madoux and Reynaud, of the Service Études de l'Électricité de France, were also successful in using a motor driven rotary borer on the Mer de Glace in the French Alps. This glacier, like the Taku, is temperate during the summer months so that water could be used for flushing. On the Mer de Glace, several holes were drilled, one to a depth of 284 m., and drilling rates of more than 10.5 m. per hour were realized (Ract-Madoux and Reynaud, 1951). In some instances, the mechanical method of sounding was used by the engineers of Electricité de France in preference to the electrothermic glacier boring method which they also employed (Nizery, 1951, pp.68-72). The reason for this was to permit penetration of debris-laden ice through which the thermic nibs often could not pass.

In the past two years three other groups of investigators have reported attempts to use motor-powered rotary drill rigs for glacier borings to great depths. Each of these groups, however, has been concerned with mechanical drilling in glaciers which are thermally classified as polar, (Ahlmann, 1949, p. 324) (Lagally, 1932, pp. 4-5), that is in the Antarctic, in Greenland and on a small ice cap of Baffin Island. As a useful preliminary to the more detailed review of the Taku Glacier drilling, a brief description is given of these polar investigations.

c. Core Boring in the Maudheim Ice Shelf, Antarctica

During the winter of 1950-51, the British-Norwegian-Swedish Antarctic Expedition used a rotary boring apparatus to obtain samples of polar firn and ice from the ice shelf along the coast of Dronning Maud Land. A depth of approximately 100 m. was attained from which core samples of 8 cm. (3.1 in.) diameter were taken. This drilling was in "cold" firn and ice with densities greater than 0.81 below the 60-meter depth. The deeper englacial temperatures averaged -12°C. (10.4°F.).

The mechanical drill used was similar to, although considerably larger than, the one employed on the Taku Glacier. It was a U.G. Strait-line rig loaned by the Canadian Longyear Diamond Drill Company. The total weight of drill and accessories was over five tons. In preliminary tests conducted on the Finse Glacier in Norway in May 1949, the size and weight of this equipment proved to be a great disadvantage. The tests were run in temperate ice in which cores of the largest rated diameter for this equipment could not be obtained. Because the drilling had to be attempted without use of water and since the first bits used were found to be mechanically inadequate, only 30 m. of ice could be bored. Only very short cores were obtained, since most of them were crushed by the rotation and grinding action of the bit and its core barrel. Another set of bits was constructed and proved to be satisfactory in the Antarctic.

The essential purpose of the Maudheim drilling was to obtain cores from which firn density and ice fabric studies could be made and to drill a hole in which temperatures of the ice shelf could be measured.

d. Recent Rotary Drill Technique on the Greenland Ice Cap

In 1950 and 1951, glaciologists of Expeditions Polaires Françaises achieved some success in drilling into high polar firn and ice on the Greenland Ice Cap. The method used was similar to that employed on the Taku Glacier, but with somewhat larger apparatus transported to the drill sites by oversnow vehicle. A one- and one-half ton rotary hydraulic diamond core drill was used. (Type SDH 200, manufactured by Enterprise P. Bachy, Paris, France. This is the same kind of unit employed by Électricité de France on the Mer de Glace.) Power was supplied by a 75 h.p. engine in one of the oversnow vehicles.

For drilling to 50-meter depths, drill stems of 57 mm. outside diameter (2.2 in.) were employed and below 50 m., stems of 47 mm. (1.85 in.) were used. As at Maudheim in the Antarctic, each hole was bored dry. A depth of 150 m. was reached in firn at the mid-ice station (circa 10,000 ft. elevation and at approximately Lat. 71°N., Long. 40°38'W.), It required 14 days with a four-man drill crew to reach this depth. At another site, near the western edge of the ice cap, drilling was conducted in dense glacier ice to a depth of 126 m. Temperatures encountered in this ice and firn varied from a minimum of -12°C. (10.4°F.) at the edge of the ice cap to -28°C. (-18.4°F.) at the center.

e. Light-Weight Diamond Drill Unit for Glaciological Research

In a recent publication concerning the glaciological program of the Arctic Institute of North America's 1950 expedition to the Barnes Ice Cap on Baffin Island, the use of a small, light-weight diamond drilling unit for drilling in "cold" glacier ice is described (Ward, 1952, pp.115-121). An X-Ray Diamond Drill, supplied by the Boyles Brother's Drilling Company, Ltd., of Vancouver, B.C. was used. It employed a gasoline motor power drive (2 and 3/4 h.p.) with about one-third the fuel consumption of the medium-sized unit used on the Taku Glacier. The chief advantage of this equipment was that the drill itself weighed a total of only 195 pounds and with its connecting rods totalled less than one-half ton. It was a convenient size for handling and moving in and out of aircraft or even for transporting by dog-team or oversnow vehicle from one glacier drill site to another.

This equipment was used in connection with studies of the permanently frozen ground around the edge of the glacier. In addition, some valuable shallow drilling of an experimental nature was accomplished in the glacier ice at temperatures of -10°C. to -12°C. (14° to 10.4°F.). It was demonstrated that such light equipment may be useful for producing a hole in the most dense ice of 3 cm. (1-3/16 in.) diameter and 100 to 150 ft. deep.

2. Purpose and Scope of Juneau Ice Field Drill Program

Initially, it was hoped that a depth of 600 ft. could be achieved with the boring equipment available. While recognizing that such a depth might not be fully reached, it was anticipated that the following investigations could nevertheless be implemented in connection with the drilling operation.

1. Mineralogic and petrofabric study of core samples of firn and solid ice to be obtained from depth. Of primary interest was the investigation of stress distribution within the glacier and studies of the nature of air bubble content in ice at the various depths.

2. Analysis of the cores for soluble salts and organic matter, and the collection of water samples for related laboratory studies.

3. Study of the stratigraphy of the bore column, in an effort to determine structural relationships, the number of years of net accumulation involved, and the depth of transition between firn and glacier ice.

4. Determination of the glacier's vertical velocity profile to the depth attained by means of periodic surveys of the alignment of a sectioned 2-in. (inside diameter) aluminum pipe implanted in one of the bore holes.

5. Insertion of a series of thermistor units in the bore holes for purposes of subsequent record of englacial temperatures, both in the thermally variable surface firn and within glacier ice to the maximum depth reached.

6. It was believed that even if all of these glaciological objectives could not be fully realized, the experience gained and the lessons learned in the drilling operation itself would be of value to future englacial boring projects.

Although only one-half the desired depth could be attained, the practical objective noted in No. 6 above was fully realized. It also proved possible to carry out some of the more important aspects of each of the proposed subsidiary investigations. Since some of these related studies are to be reported on in detail in other publications, the purpose of this report is primarily to describe the drill technique employed and to evaluate the method for further use in glaciological research. A resumé of the scientific observations in the bore holes is also presented here and the observational data are included in the appendices. Special mention is made of the subsequent deformation of the jointed aluminum pipe which was successfully inserted into the deepest hole; however, at this time only a few preliminary comments are made on the interpretation and significance of these records.

3. Selection of Drill Site and Equipment Used

The drill site selected was at Camp 10B in the central half of the upper Taku Glacier at 3575 ft. elevation and about 1 mile west of the Camp 10 research station (Figs. 2 and 3). This location was chosen because here the glacier's depth was known, by seismic means, to be greater than the proposed drilling limit of 600 ft. Depth of the ice at this point is about 1000 ft.(Miller, M. M., 1952). This site also represented, in terms of surface and englacial flow, a more significant section of the glacier than one nearer the margin. Logistically, the location was ideal since it was adjacent to previous camp locations and because heavily-laden ski-aircraft could easily make landings at the site.

The only drawback, far outweighed by the advantages, was that the site was too near the middle of the glacier to permit the use of water from any of the ephemeral melt-water streams flowing from the bordering nunataks. With water as a continually available flushing agent with which ice chips could be removed from the core bit, much greater rates of advance were known to be possible than when drilling "dry". However, since the Taku is a temperate glacier in which water becomes locally impounded in crevasses, it was believed possible to pump water from that source. The equipment was therefore set up in the vicinity of several crevasses and within 20 ft. of the largest one which could be located at the time of the initial supporting flights (See Fig. 4).

The drilling apparatus and accessories, flown to the ice field by ski-aircraft, consisted of the following:

(a) Drill Assembly, comprising a Pioneer Straitline Diamond Core Drill, (manufactured by the E.J. Longyear, Co.) with motor and hoist. The drill was mounted on a steel frame and was powered by a water-cooled, four cylinder, Waukesha gasoline engine developing up to 10 horsepower. The engine operated at 1800 r.p.m. and transmitted, through its transmission to the bit, rotating speeds of 305, 450 or 880 r.p.m. The motor had a fuel consumption of three to five gallons per eight-hour shift. A clutch positioned between the engine and a three-speed transmission allowed instant stopping of the drill without shutting down the motor. Any one of three drill and hoist speeds could be employed. The transmission was an automotive-sliding gear type with gear ratios of 3.2 to 1; 1.9 to 1; and 1 to 1. Hoisting speeds of 70, 120 and 225 ft. per minute were available. On the hoist, a sensitive control for the rotating drum allowed for 65 ft. of 5/16 in. cable and for the drill rods to be picked up and raised or lowered smoothly while the motor was running. The weight and dimensions of individual parts of the drill-motor assembly were:

	Weight	Dimensions
Straitline Drill (including transmission and swivel head)	455 lbs.	4'11" long 2'10" wide 4'10" high
Waukesha Motor	300 lbs.	---
Frame Mounting	185 lbs.	3'7" long 2'10"wide 2'0" high

Total Weight 940 lbs.

This equipment was designed for exploratory work in geological prospecting where it is capable of drilling 1-½ in. diameter holes in bedrock to a depth of 600 ft. At its maximum rated depth, cores of 7/8 in. diameter may be recovered. For shallow drilling, as on the Taku Glacier, holes greater than 1-½ in. can be drilled by using larger rods.

(b) The motor-pump assembly consisted of a Racine variable-volume oil hydraulic pump which was placed on the drill platform, and a heavy-duty Fairbanks-Morse deep-well pump at the source of water supply. The Racine pump provided requisite circulation of water from a storage supply into the casing and the bit assembly. The deep-well pump, set on planks over the water supply crevasse, drew water into a tarpaulin-lined storage pit from which it was pumped into the drill hole. The net weight of the motor pump assembly was approximately 850 pounds.

(c) Accessories consisted of the following items: steel tubes for the tripod, planking and lumber for the drill platform and tools for the assembly and maintenance of the various pieces of equipment. Although the combined weight of the drill pump including tools was slightly less than one ton, the additional weight of the necessary structural and building materials, plus the weight of core barrels, drill stems, steel casing (for the drill hole), packing crates, lengths of aluminum pipe, drums of motor oil and gasoline, and so forth, brought the total to more than seven tons of accessory equipment.

4. The Core Drilling Operation

Since it was not until May, 1950, that the Longyear Company could definitely commit itself to furnish drilling equipment for the project, insufficient time remained before the start of the summer field season to design and construct a desirable large-diameter core bit for use with the available standard gauge equipment. It was recognized that the larger the core diameter the less disturbance would occur within the samples to be obtained for study. A laboratory test conducted by Dr. H. Bader in the Engineering Experiment Station at the University of Minnesota, however, gave good indications that it was feasible to obtain cores of solid ice with a standard NX core barrel which normally produces a 3-in. diameter hole and a 2-1/8 in. core. Thus, planning centered around obtaining samples of clear ice of this dimension and around the other glaciological investigations which would be made possible by drill holes of 3-in. diameter.

The 34,000 pounds of equipment were assembled and shipped by rail and steamer to Juneau in June. In the first week of July, the heaviest items of drill equipment were delivered to the Camp 10B site. Due to bad weather and unavoidable delays in the arrival of several key personnel, the drill operation could not be begun until the 31st of July. In Appendix I is the log of drilling in which is also included some of the day by day details of field operations. A period of 36 days was involved in the program at the drill site. This included the initial inventory and erection of boring equipment and the time necessary for dismantling and packaging the equipment for removal from the ice field in September.

Because the first two days were spent in construction of the drill platform and tripod and installation of the drill and pumps, actual boring was not begun until August 3rd. A period of 15 days of effective drilling was then spent on Hole No. 1 (to 292 ft.); three days on Hole No. 2 (to 94 ft.) and eight days on Hole No. 3 (to 175 ft.). The remaining ten days were devoted to auxiliary and repair aspects of the boring operations.

(a) The Progress of Drilling in Firn and Ice

Most of the drilling was done with an NX double-tube casing and a four-tooth bit on a swivel barrel. Certain difficulties were encountered in the firn which made study of samples from the upper half of the deepest hole unsatisfactory. The small diameter of the standard core barrel tended to crush and distort sections of the firn in such a way as to render it difficult to remove useful samples. In many cases, the result was the development of a corpuscular structure of compressed firn, forming pod-like segments or monocles of pressure ice. These were usually lentil-shaped in form and alternated rhythmically with layers of relatively uncompressed firn. Only a few discs from some of the thicker and more resistant natural horizontal ice strata survived within the core barrel; however, these could sometimes be mistaken for compression structures. The rhythmic artificial structures were termed "compression" ice pods. Since they were mechanically produced, they not only obscured and confused the interpretation of stratigraphy of the firn cores, but appeared to have no significant meaning in themselves.[4]

In the following table is shown the basic differences between the so-called artificial "compression" ice pods and the discs of natural and relatively undisturbed ice strata which were found in some samples.

[4] It is of interest, that on the recent French expedition to the Greenland Ice Cap, cores of 1-1/32 in. diameter, half the size of these from the Taku Glacier, likewise suffered severe distortion and the development of compressed ice structures, similar to those described here. The glaciologists on the French expedition applied the term "monocle ice" to these features.

Distinguishing Characteristics of "Compression" Pods in Core Samples	Distinguishing Characteristics of Natural Ice Discs in Core Samples
1. Fairly uniform distribution, 1 to 2 in. apart	1. Irregularly spaced
2. Rhythmically alternated with layers of relatively uncompressed firn	2. No rhythmic alternation with firn layers
3. Occasionally dumb-bell shaped or concave-sided	3. Usually flat-sided, at least on lower side
4. Many of the pods look like "monocles" or convex lenses	4. Usually in the form of true discs; not monocled or lens-like
5. Relatively darker and denser than firn, but slightly less dense than natural ice	5. Very hard, true natural ice
6. Fairly fine-grained in upper firn; more permeable than the intermediary firn zones (as tested by the percolation of water-borne fluorescein dye). Ice lenses represent fracture zones and due to granulation are permeable in any direction. More permeable than ice discs in horizontal direction.	6. Crystal size usually larger in upper firn. Fluorescein dye penetrates very slowly and vertically only along distinct fracture planes or intercrystalline sutures. Best permeability is horizontally; however, much less permeable than firn and ice pods.
7. Not many air bubbles in the ice lenses; nor water bags	7. Transluscent to clear and characterized by air bubbles and water bags.
8. Lenses often fractured in center	8. Discs not fractured
9. Relatively thin, ½ to 1 in. thick	9. On average, tend to be thicker; 1/8 to 8 in. depending on thickness of ice stratum represented
10. No corollary macroscopic characteristics	10. Occasionally locus of dirt and organic matter

Difficulties were also encountered with the supply of flushing water. On the day that drilling began on Hole No.1, the 54- to 59- ft. water level which had prevailed during the latter half of July in the nearby supply crevasse, (over which the deep well pump had been installed) suddenly dropped 6 or 7 ft. This was undoubtedly the result of drainage to a new and lower local water table as caused by minor adjustments in the fracture pattern of the crevasse system (Refer to Table V). The water table came to rest by August 4th at 73 ft. below the firn surface, but pooling in the source crevasse was in such a narrow section that it precluded the well pump feeder tube reaching it.

During the summer, locally perched water tables of such ephemeral nature are quite common. Generally, however, a constancy of water level appeared to be shown from one crevasse to another. It was therefore reasoned that if a steel casing could be inserted into the drill hole in the firn to a depth below the water table (as measured in crevasses adjacent to the drill site), re-circulation of a limited supply of water could be achieved. It was believed that drainage from the casing would be so slow that drilling could proceed at least with the pump operating at a sufficient pressure to make up for losses.

Thus, the steel casing was inserted to 74 ft. and filled with water from the tarpaulin-lined storage pits. However, bubbles were soon seen rising in the tube and the water drained out too fast for use. Further drilling, therefore, had to proceed without water. This considerably slowed down the rate of advance.

Drilling through the firn took four days at the reduced boring rate. All the cores were structurally analyzed as they were brought to the surface and each was melted and the resulting melt-water decanted for subsequent pollen-analysis. This record, unfortunately, was obscured by the churning action of the drill. At the 120- to 121-ft. level, an abnormally rapid advance was made while drilling without water. This suggested that the advance was still in firn. Definite cores of firn were taken between 100 and 119 ft. From 121 to 126 ft., drilling was attempted with a four-tooth bit, cut by hack saw out of an NX casing coupling in the hopes that the slightly larger inside diameter (3 in.) might make it possible to obtain better and less disturbed cores from this critical transition zone.

The water level in the bore hole appeared to rest at 110 ft. on August 9th. (This seemed rather deep for the summer water table and may not have represented its true position because of induration of the walls of the bore hole or because of water seals caused by impermeable ice strata.) The hole was reamed with NX casing and a 130-ft. casing was inserted to reach below the observed bore hole water level. After filling the casing with water, however, drainage again occurred from below, at a rate of 5 in. per minute. Therefore, recourse again had to be made to dry drilling. The cores continued to be quite distorted and mashed for the next 20 ft., so that unfortunately little could be learned from them. Below 139½ ft., however, continuously solid ice was penetrated. The depth of firn along this profile thus may be stated to reach at least 120 ft. A firn-ice transition zone probably occurred between 120 and 140 ft. and below 140 ft. there existed only dense glacier ice.

Dry drilling was continued to a depth of 181 ft., with broken ice cores being obtained. On August 15th, the water level in the source crevasse had risen to 65 ft. and was reached after a relocation of the deep well pump. A higher rate of drilling was thereafter accomplished with the aid of flushing water and better cores became available for mineralogic study. From 200 to 292 ft., good cores of consistently solid ice were obtained. Some of these were brought up in unbroken lengths five to six ft. long. The cores were wrapped in wax paper and stored in the cold laboratory for analysis.

At the 161-ft. depth, another unexpected problem arose. As a result of clockwise rotation of the drill rod and ensuing friction on the side walls, the right-hand threaded casing had gradually become unscrewed at one of its connections. The bottom 40 ft. of casing thus loosened and became detached. This occurred at the 110- ft. level. The upper 110 ft. were withdrawn from the hole but all efforts to remove the detached section were unsuccessful. Although this did not prevent further drilling at the time, it was eventually to cause the abandonment of Hole No. 1. For a few days it was possible to continue drilling with the rods passing down through the detached unit of casing. The loose section served as a "bearing" for the rotation of the drill stem and hence, for a brief period, actually speeded the drilling rate. A depth of 292 ft. was eventually reached while drilling with the intermittent use of water. (The water level continued to fluctuate in the nearby fissure. See Table V and Appendix I.)

At the time that the 292-ft. depth was reached, the 40-ft. section of loose casing, which had been clinging to the side of the bore hole, further detached itself by frictional unscrewing so that a lower 10-ft. section dropped to the bottom of the hole. Shortly after this, the remaining 30 ft. of casing slipped farther down the hole and struck its basal section at a slight angle. The tilt was estimated to have caused a horizontal displacement of 1 to 2 in. A completely unexpected jamming of the hole resulted from this freak occurrence. The drill rods thereafter could not be passed through the bottom 10 ft. of casing. All further removal efforts were unsuccessful, due to a "slush block" of ice chips and water which had developed at the junction between the two detached sections. Since the core barrel could not penetrate any deeper, the bore hole was abandoned at the 292-ft. level. The 40 ft. of lost casing was left resting vertically at the bottom of the hole. Coincidentally, water in the supply crevasse again suddenly drained out so that further flushing liquid was not available.

The upper 252 ft. of the hole was cleared of drill rods and on the 20th of August, 228 ft. of 2-in. (inside diameter) aluminum pipe, in 10-ft. jointed sections, was inserted into the drill hole for purposes of future englacial movement studies of the type carried out on the Jungfraufirn in the Swiss Alps (Perutz, 1950, pp. 382-383). On the 22nd of August, the initial alignment survey of this pipe was completed and drilling was then commenced on Hole No. 2 (Fig. 4b).

The second hole was drilled 5 ft. south of Hole No. 1. While boring proceeded in firn, water was not used. Unfortunately, a depth of only 94 ft. was achieved in this hole. At that level, another unexpected situation arose. Between $54\frac{1}{2}$ and $61\frac{1}{2}$ ft. below the drill platform, an opening of 7 ft., in vertical dimension, was encountered. It was believed to be an alcove of a buried crevasse. This caused the lower 50 ft. of drill rod to unscrew at the

54-ft. horizon, apparently due to a "whipping" action which developed in the open space. A section of NX casing was lowered and hammered down to 59 ft. in the hope that it would hook over the lost rod and allow it to be rethreaded. Unfortunately, all efforts to recover the rod failed. Hole No.2 was therefore abandoned at the 94-ft. depth. The remaining rods and casing were removed and the drill machine was shifted to another position four and one-half ft. west of Hole No. 2. The tripod was also shifted to cover this new location.

On August 27th, drilling was begun on Hole No. 3. For this work, a six-toothed bit was employed on the NX double-tube barrel. Drilling was undertaken dry and continued to 75 ft. at a rate of 6 ft. per hour. On the 28th of August, the water table in the hole was reached at the 50-ft. depth. Water had also risen in the crevasse to this same depth thus considerably speeding up the boring program. At the 70-ft. level, water was again applied for flushing out the ice cuttings and a faster rate of advance was achieved. Below this depth, the effects of rotation and reduced pressure within the barrel tended to freeze the flushing water, a factor which slightly slowed down the operations. By August 30th, a depth of 102 ft. was reached and on September 2nd 175 ft. was attained. Lateness of the season and the scheduled arrival of the Air Force's supporting ski-aircraft brought the season's drill program to a close. Several days were spent in dismantling the gear and in preparing it for evacuation.

(b) Practical Results and Lessons Learned

A review of the drilling details and consideration of the field conditions and organizational aspects involved in this phase of the summer's program provides some useful notes and conclusions.

The availability of drilling equipment was not assured at an early enough date to permit the design and construction of a large diameter coring bit. Thus, standard equipment had to be employed which, for purposes of drilling in ice, needed some modification. The relatively small bits which had to be used, and which produced 2-1/8 in. diameter (55 mm.) cores, compressed and fractured the firn when it was forced into the core barrel. Apparently also most of the snow under the cutting edge was forced into the barrel. To alleviate these conditions, a larger diameter bit and a core bit taper with a sharp contact edge are necessary. Single tubes may also be better than double ones, at least for coring in firn.

In the Taku Glacier drilling, for the reasons mentioned above, a three- to four-ft. advance in firn often resulted in a ten-ft. core of highly disturbed material with artificial ice pods developed at one- to two-in. intervals. A somewhat similar type of core often results from dry drilling in solid glacier ice, with the space between the solid ice zones being occupied by cuttings which are macroscopically quite difficult to distinguish from firn. When drilling was done in dense ice using water, for a reason not yet fully clear, only the upper three to six ft. out of each ten-ft. core sample was retrieved intact. The rest of the core was segmented by a series of small broken fragments. In drilling through solid ice, however, even though some fracturing and granulation occurred, those portions of the cores which were intact did not show any rotational deformation. As in firn samples, the indicated effective stress was mostly compressional.

The primary reason that the desired depth could not be achieved is attributed to the difficulty encountered in feeding a steady supply of water to the core barrel. If the crevasse source had not repeatedly failed, due to englacial adjustments and unexpected drainage, it would not have been necessary to resort to the use of casing for re-circulation of a limited supply of water. Closure of the deepest hole, due to loss of a lower section of casing, would therefore not have occurred. If it had not been for this factor, it is believed that the maximum rated depth for the equipment might easily have been reached during the time available for this drilling operation.

A period of two weeks of severe weather during the last half of July also prevented arrival of the supporting ski-plane, which caused a 10-day delay in commencement of the drilling program. This additional time could have been used to much advantage in the solution of field difficulties later encountered and in the attainment of greater depth in Hole No. 3.

It is considered important that in any such future drilling program, two full-time rig assistants be made available to the driller. In the original planning for this work, it was advised that one assistant would be sufficient, with any extra needs being met by other members of the project. The unexpected difficulties in operation were such, however, that another man could well have been used. This is also important so that the scientists on hand to study the ice cores and to conduct related investigations will be able to devote maximum effort to the scientific aspects of the program.

(c) Summary Notes and Technical Recommendations

The following recommendations are made for future mechanical drill operations in an isothermal ice mass such as the Taku Glacier:

1. Assure that a ready supply of water will be available for flushing.
2. If possible, utilize left-handed thread drill rods and casing (or well-resined right-hand threads) with any normally clockwise rotating drill unit.
3. Utilize as large a diameter drill bit and core barrel as possible in order to reduce compression deformation of samples, especially in firn. One which is at least 3 to 5 in. (76 to 127 mm.) in diameter is desirable.[5]
4. It is recommended that the core barrel should have a toothed crown on top, so that it can be drilled up through an obstruction if one should be encountered during retraction of the equipment.
5. An hydraulic drill feed mechanism is recommended.

[5] Undisturbed cores of 80 mm. diameter (slightly more than 3 in.) were successfully obtained in cold firn from a 5 in. diameter hole at the Maudheim drill site in the Antarctic.

The following technical results and comments from this drilling program are also summarized:

1. The mechanical rotary drill method for drilling in temperate glacier firn and ice is very feasible as long as the above recommendations are kept in mind.

2. Good cores of ice are obtainable, even with a relatively small diameter corer, if ample flushing water is available.

3. For low gradient glacier work, casing is not necessary in firn. No collapse was experienced in the hole on the Taku Glacier.

4. Less danger of cuttings causing a "slush block" will result when drilling is done below the local firn water table.

5. Drill-bits with 4 to 6 teeth are quite satisfactory.

6. In the late summer of 1950, the firn at the Taku Glacier Camp 10B site (3575 ft.), extended to 120 ft. and was not more than 140 ft. below the early August névé surface. Below 140 ft., solid glacier ice existed.

7. A variable water table existed in the firn at the Camp 10B location in the summer months. The level of the water table periodically rose and fell between the limits of 50 and 74 ft. in response to continual readjustments in the glacier's drainage at depth.

G. Englacial Investigations

The program of englacial investigations resulting from the boring operations essentially embraced studies of the physical nature of the cores and of glacier movement and temperature conditions at depth. Each phase of this research is described below, with a few preliminary comments on the interpretation of results.

1. Analysis of Core Samples

A megascopic study of each core sample was made as the boring proceded. In the drill log (Appendix I), the evidence is presented that firn was encountered to a depth of 120 ft. Because of the compression introduced by wall friction within the core barrel, each sample was too disturbed for a reliable columnar section to be made. This also made it impossible to obtain accurate determinations of specific gravity. The analyses of solid ice cores from below the 140-ft. depth were more successful.

Petrofabric studies of the ice cores were undertaken in the cold laboratory dug 15 ft. into the firn near the drill site. Of 6- by 8-ft. horizontal dimensions, it had a 7-ft. ceiling made from a wooden frame of shiplap which was covered with water-proof tar paper. Eight ft. of snow were shovelled onto this roof to effectively shield off solar radiation and the vertical percolation of free water. A narrow doorway was opened into the northern side of the enclosure which could be reached only by descending a narrow stairway also shielded from the sun. Thus, the air and firn within the cold laboratory were kept at freezing temperatures.

As drill cores were brought to the surface, they were logged, analyzed macroscopically and then placed in core barrel packing crates for temporary storage in the cold laboratory in a series of elongated wall recesses. The project's mineralogy team, Dr. Henri Bader and G. Wasserburg, worked in the cold laboratory in two to four-hour shifts alternating in the analyses of cores. Their work was primarily concentrated on a description of the crystal size and fabric and on their orientation in ice cores from the 150- to 292-ft. depths. Representative samples from each 10-ft. run were thin-sectioned with a hack-saw. They were then placed in a specially constructed three-axis universal stage, refrigerated by immersion in a jacket of ice water. Thus, the sample was kept from melting while being studied under polarized light. The orientation of the C-axis in individual crystals was measured, care being taken to differentiate different grains of the same crystal in each thin section. The C-axis positions of the crystals at each reference depth were then plotted on a stereographic projection for further analysis at a later date.

Preliminary results of the petrofabric investigations, provided by Dr. Bader and G. Wasserburg for mention in this report, have indicated the following:

1. From the surface to 140 ft., the C axes of all ice crystals analyzed were, for the most part, at low angles to the horizontal and with no preference in azimuth.

2. At the deeper levels, below 140 ft., the C-axes of individual crystals were still preferably horizontal rather than vertical with a mean angle from the horizontal of less than 30 degrees.

3. From 140 ft. to the base of the bore at 292 ft., there was a progressive crowding of azimuth values towards the vicinity of a line of unknown orientation, presumably either normal or parallel to the direction of flow.

4. No truly systematic variation of crystal fabric was observed over short intervals. Actually, there was alternation between good preferred orientation and more random orientation over short increments of depth. This, however, may have been related to retained local differences in relict primary stratification.

5. At shallower depths, crystal sizes were smaller and the order of magnitude was measured in millimeters.

6. At deeper levels, crystal size increased to the general order of magnitude of centimeters.

7. Most of the ice samples exhibited an interlocking network of crystals.

8. A moderately uniform spacing between relatively equi-dimensional air bubbles was noted. Each air bubble was associated with a water bag.[6]

A special study of the nature of the water bags and air bubbles and their probable significance was carried out. The results of this work are now being prepared for inclusion in the detailed report of the crystal fabric studies. A description of the three-axis water immersion universal stage used in these analyses, as well as of the general technique employed, has been presented by Dr. Bader in a recent paper (Bader, 1951).

2. Englacial Movement Studies

It has been possible, on four subsequent visits to the ice field, to record the deformation of the 245-ft. length of 2-in. aluminum pipe left in Bore Hole No. 1. From these records, the nature and magnitude of down-glacier firn and ice movement within the Taku Glacier can be assessed over a period of 25 months. The technique employed in the deformation surveys was similar to that used in recent measurements of the velocity distribution on a vertical line through one of the tributaries of the Aletsch Glacier in the Swiss Alps (Gerrard, Perutz, and Roch, 1952).

(a) Surface Displacement of Bore Hole Pipe Since Original Installation

The survey team triangulated the surface position of the aluminum pipe on September 15, 1950. The method used was the same as employed for the across-glacier movement stake records. The pipe's surface position has subsequently been re-surveyed on the dates shown in Table VII. Also, in this table are given the surface displacement and directions of movement during the several intervening periods of record.

[6]For a discussion of the nature of these forms and their investigations refer to Bader, 1950, pp. 443-451.

Table VII

RELATIVE POSITIONS OF TOP OF ALUMINUM PIPE (STATION 10B), 1950-52

Date of Record	Horizontal Distance from Sta. 19 (Camp 10)* (in ft.)	Total Calculated Movement Since Previous Date (in ft.)	Daily Movement (ft.)	Direction of Movement since previous Record** True
26 Aug., 1952	5495	159	4.2	152
19 July, 1952	5369	596.4	1.85	114
2 Sept.,1951	5408	101	1.66	128
3 July, 1951	5416	209.6	1.65	---
26 Feb., 1951	5463	10	1.65	126
20 Feb., 1951	5463	32	2.3	---
6 Feb., 1951	5463	266	1.86	---
15 Sept.,1950	5487 (-25)	---	----	---

Total horizontal displacement between Sept. 15, 1950 and Aug. 26, 1952 approximately 1374 ft., averaging 1.8 ft. per day in an average direction of 130° (T) during this 25 month period.

(b) Instrumentation and Technique Used in Bore Hole Surveys

For lining the bore hole, Alcoa aluminum pipe (S.P. 61-S-T6, 2 in. I.D.), in jointed 10-ft. lengths was used. Initially, sixty-five individual sections were provided totalling 650 ft. In addition, seventy couplings (2-3/4 in., O.D.) were purchased to permit joining these lengths together as they were passed into the hole. Two terminal plugs were also used as inserts at the top and bottom of the full length of pipe. At each joint, thread lubricant was applied to form watertight seals. A pipe thread cutter with handle, two strap wrenches, and four one-half pint jars of Alcoa Lubricant were necessary items of equipment.

For survey of the interior of the pipe, after it was implanted in the glacier, a small-sized magnetic azimuth-inclinometer was employed. The type used was one which is standard in oil well hole surveys, - a Single Shot Bore Hole Survey Instrument loaned by the Eastman Oil Well Survey Company of Denver, Colorado.

This instrument records simultaneously the magnetic direction of the course of the drill hole and its deviation from the vertical. The meter encases a camera, the trigger of which is pre-set by clock mechanism so that photographs can be taken of the position of an internally placed pendulum bob with reference to a compass card in an angle indicating unit. The instrument is 23 in. long and one and one-half in. in diameter. For the Taku Glacier work, it was enclosed in a four-ft. protective barrel which the Eastman Oil Well Company had manufactured especially for use in this pipe.

*On bearing 225° T. from Station 19 as of Sept. 15, 1950 and 209°T. as of Aug. 26, 1952.

**Bearing in degrees from true North.

The protective barrel was made out of brass with a 1-3/4 in. outside diameter to allow it easily to pass through the 2-in. tubing of the bore. It was provided with a non-magnetic stainless steel sinker bar which could be connected to the barrel with a universal joint to permit the assembly to pass over possible doglegs in the pipe. Actually, it proved to be easier to lower the barrel into the tube without the sinker bar. Thus, it was not attached and the haulage wire was screwed directly into the universal joint.

A list of equipment essential to the bore hole surveys is given below.

Inside Single Shot Instrument
12-degree angle unit
2, loader assemblies, with 40 record discs in each
Double-solution film tank and unloader assembly
2, instrument watches (33-minute), one as spare
Magnifying reader's lens
2, porcelain glass developing jars (numbered 1 and 2)
12 packets MQ Photographic Developer
2 cans, Photographic Fixer (Hypo)
1 carton of 8 heavy-duty photo-flash batteries
1 carton of 10 light bulbs
Comparing watch (45-minute)
4, bottles for mixed developer and fixer (12 oz.)
Kit box
6, rings for bull plug (top connector to haulage wire)
1-3/4 in. (O.D.) barrel assembly, including bull plug, barrel, sinker bar and top connector
Set of assembly and dis-assembly wrenches
650-ft. length of 1/4 in. steel haulage cable
Hand winch and measuring sheave

For field reference, the most expedient sequence of survey operations is as follows:

1. Set instrument on shaded snow surface for one or two hours before use so that its temperature will reach the freezing point.
2. Prepare a bucket of fresh water for rinsing.
3. Open instrument and check light bulbs.
4. Insert film with loading mechanism on camera slot of instrument, pressing release knob to insure light-tight connection.
5. Wind clock work (being careful not to overwind) and pre-set to a tripping interval of sufficient duration to allow instrument to be placed in protective case and lowered to desired depth. Synchronize instrument watch with 45-minute surface comparing watch and set comparing watch.
6. Close instrument and place in protective barrel
7. Lower instrument and barrel to designated depth (each 5 to 20 ft.)
8. Note tripping time on surface watch. It is advisable to wait 10 seconds longer and then haul instrument to the surface.

9. Remove instrument from barrel and unload record disc into film tank making certain that the handle on the unloader is closed before removing unloader from instrument.

10. Place film tank in porcelain container No. 1, which is filled with developing solution. After proper development at temperatures involved, drain tank of developer and place in container No. 2, with fixing solution. Leave in fixer for several minutes. Then, remove single shot disc from tank and rinse in fresh water. (In cold water, develop at least 5 minutes; fix for 5 to 10 minutes, and then rinse well in fresh water.)

11. After each operation, rinse film tank with fresh water and reload for next survey.

12. Double every second survey reading for accuracy check.

13. Enter depth of successive records immediately into notebook, using as upper reference plane the 15-ft. level above the drill platform.

(c) Record of Periodic Azimuth-Inclination Surveys

The several surveys of the pipe's deformation which have been made to date are noted in Table VIII. Details of the records obtained are listed in Appendix J. Vertical cross-sectional views of the pipe's deformation in down-glacier and across-glacier directions are given in Fig. 14. Plan views of the three-dimensional survey at four successive dates are shown in Fig. 15.

Table VIII

DETAILS OF DEPTH AND INCLINATION IN THE TAKU GLACIER BORE HOLE SURVEYS

Date	True Vertical Depth of Survey Below Reference Plane* (in ft.)	Time Increment Since Previous Record	Max. Drift Angle	Survey Disc Spacing and Remarks
22 Aug., 1950	245		1°05'	20 ft.
11-17 Feb., 1951	244.96	6 months	2°00'	5 to 20 ft.
17 June, 1951	239.95	4 months	3°00'	15 ft.; spare protective casing lost in bottom 5 ft. of pipe
14 Sept., 1952	222.73	15 months	7°15'	10 to 20 ft.; only false bottom attained, 22 ft. from true bottom of pipe

*Reference level, 15 ft. above wooden drill platform; approximate position of mid-February, 1951, snow surface.

(d) Instrumental Accuracy and Plotting Method

In the six-month increment survey for February 17, 1951 (Fig.14), there is approximately six in. of displacement shown. This is considered to be well within the accuracy of the survey instrument. The Engineering Office of the Eastman Oil Well Survey Company, in reply to a query concerning this matter, has stated that "we have found, over a number of years, that our surveying instruments are accurate within 0.25 % or less. This is the maximum percentage error in calculated diameter of the vertical depth. To our knowledge, there are no instruments being manufactured which have any greater accuracy."

The calculations and plotting of results in Figs. 14 and 15 are based on straight line distances between the survey points. With the measured drift angles, each surveyed length is considered as one side of a right triangle from which the other two sides are calculated. From this is obtained the true vertical depth and the horizontal deviation. For a ten-ft. course length, with for example an angle of one degree, the vertical depth is 9.998 ft. and the deviation horizontally is 0.175 ft. The calculations are only carried out to two decimal places, thus giving the vertical depth of 10 ft. and the horizontal displacement of 0.18 ft.

This means that for measured course lengths of 10 ft. along the pipe, at one degree there is no loss in vertical depth. A 100-ft. length would then ideally show only a loss of 0.02 ft. in vertical depth. This gives an almost negligible difference between the measured depth along the pipe and the true vertical depth. The small differences which do exist may be calculated mathematically by multiplying the course length by the cosine and sine of the angle recorded on the particular single shot disc in question.

In the plotted diagrams, all survey points have been connected with curved lines. This tends to smooth out any abrupt turns which might actually exist. The general trend of the curved line, however, shows a reasonably accurate projection of the pipe. For more precise records, the survey points could all be taken at 5-ft. intervals; however, this was not deemed necessary for the purpose involved. The value of shorter course lengths between points, of course, would be that any sequence of survey point locations would more closely approximate the true curve of the bore hole.

The change in absolute elevation of the top of the pipe over the horizontal distance moved down-valley to date has been on the order of 20 ft. On such a low-gradient glacier this does not introduce complications in the interpretation. Each plotted survey is therefore shown from the surface downward and represents the measured depths along the pipe. If true vertical depths are desired, they are listed in the appendix for each reference level and date of survey.

(e) Preliminary Assessment of Results

The deformation of the aluminum pipe is a direct reflection of the nature of differential glacier movement at depth. This is on the assumption that no errors have been introduced into the record by vertical slippage in the bore hole, since it is believed that the pipe has been locked in place by the protuberances caused by the larger diameter of couplings at 10-ft. intervals. It has been noted that during the more than two years which have elapsed between the initial and most recent surveys, the horizontal down-valley distance moved by the top of the pipe has been 1374 ft., at an average velocity of 1.8 ft. per day. The increments of successive surface transfer between the periodic surveys are also known. In general, the nature of the surface-versus-depth movement is similar to that observed in the Jungfraufirn measurements of 1948-50 by Gerrard and Perutz. However, since the Taku Glacier surveys were more detailed, they indicate local irregularities in the deformation which are not apparent in the results of the Jungfrau investigations (Gerrard, Perutz, and Roch, 1952, p. 553).

It is apparent from a study of the plotted records, that in this portion of the Taku Glacier a slightly greater flow occurs in the surface zone than at depth in the general direction of mass transfer. (Southeasterly, average 130°T.) Locally, there is a lateral component of differential movement which is tipping the upper section of the pipe across glacier in a northeasterly direction. This is most pronounced in the fifteen months increment represented by the 1952 survey and is a situation which is difficult to reconcile in view of the general direction of down-glacier flow. It may be of interest that in the summer of 1952, an apparent change in direction of surface movement was measured with the latest direction 152 degrees T. This may possibly be attributed to the fact that the sub-glacial slope, as indicated by surface gradient, inclines more towards the center of the glacier at this location than it does in the down-valley direction. This is well shown by the névé surface, one-half mile southwest of Camp 10B, where the gradient increases to 3 or more degrees. However, perhaps more important is the fact that also near the drill site there is a slight increase in gradient towards the east which may explain the transverse tilt recorded in all deformation surveys until the summer of 1952. (Compare the two cross-sectional plots at right angles to each other in Fig. 14.) Subsequent surveys should show whether the indicated trend continues.

The lower 200 ft. of pipe exhibits a much more uniform inclination in the Southwest-Northeast plane than from the surface to the 95-ft. depth. (Note especially the curve between 95 and 245 ft. on the survey of September 14, 1952.) This most striking change shows up well between 85 and 105 ft. The point of flexure actually begins at the 115-ft. depth (well shown on the curve for June 17, 1951), which position is 100 ft. below the August 1950 surface horizon. It is significant that at this depth the analyses of drill cores in 1950 showed a marked physical change from firn in the upper column to solid crystalline glacier ice below. It may, therefore, be concluded that this marked difference in pipe deformation in the diagrams is due to relatively more rapid transfer of firn over the mass of subjacent glacier ice. In the right hand plot in Fig. 14, a second flexure occurs at the 165-ft.

depth which cannot be so easily explained. At greater depths, there is a distinct reversal of slope on the plotted curve suggesting a differant rate of flow at deeper levels. The uppermost flexure, however, appears to be caused by low-angled firn creep. The relationships here briefly noted will be illustrated in a subsequent report by a plot of drift angle as a function of depth in two directions of the down-glacier flow. In this plot, comparison will be made with the curves of firn creep in seasonal snow-packs as have been measured by Haefeli (1948) in the Alps.

In the plan views of Fig. 15, the flexure relationship is particularly well shown at the 105-ft. depth. The smoothness of the upper part of the curve, above the firn-ice contact, and the spiralled nature of deformation below it may partially be the result of initial alignment of the bore hole. Such, however, would not explain strong development of the deeper flexure in the major direction of down-glacier movement at 165 ft. (150 ft. below the August, 1950, surface).

Neglecting local irregularities in the curve, over-all tilting of the full length of pipe is well evidenced even for the shortest periods between surveys. This tilting is especially well shown in the plan views where the horizontal distance of closure between the top and bottom of the pipe has shown an increase of several ft. over the interval of 25 months. At the 222-ft. level in August 1950, the closure was 2.52 ft.; whereas by September 1952 at 223 ft., the closure had increased to 5.98 ft. As far as the true bottom of the pipe is concerned, this latter figure is a minimum since the lowest 22 ft. could not be re-surveyed in 1952. In Fig. 14, dotted line projections representing the unsurveyed portion of the basal section show the probable relationship. For comparison, at the extreme base of the pipe, the total closure indicated was 2.71 ft. in August 1950 and 6.25 ft. in September, 1952 with the direction of tilt averaging South 55° West. It is mentioned again that this is the across-glacier component approximately perpendicular to the primary direction of down-valley mass ice transfer.

An interpretation of the creep rate of the firn and ice as a function of shear stress within the glacier and as shown by the differential deformation and down-glacier displacement of this pipe is also being made for inclusion in another report. For this fundamental analysis additional surveys of the pipe will yield most valuable and interesting supplementary information.

3. Analysis of Cores for Soluble Salts and Organic Matter

From drill cores obtained in Bore Holes Nos. 1 and 3, samples were taken for analysis of the percentage of naturally contained soluble salts. Since, as is described in the 1951 summer report, sodium chloride is considered to be the only constituent found in any significant quantity, the analyses were concerned with the percentage determination of the chloride ion. The laboratory determinations were made by H. Kothe (at the Fleischmann Laboratories in New York City) who, as a member of the

1950 field party, aided in collection of the samples. The results of the 1950 work are tabulated in the report of the winter expedition, of 1951, wherein they are listed in comparison with determinations from samples of winter snow taken at the 10B site in February 1951. The technique of laboratory analysis and the field methods used in obtaining these samples without contamination, are also described in the 1951 winter and summer expedition reports. For comparison, supplementary samples were obtained in August and September 1952 from the firn cover on the upper Taku Glacier at 5800 ft. elevation.

Most samples have been taken from pit walls to depths of 20 ft. In this season, however, the deep rotary drill cores permitted them to be obtained in firn-ice and glacier-ice at depths of 100,110,125,160,170,243, and 276 ft. below the mid-summer ablation surface.

Fifty bottled samples of water (50 cc. each) were obtained from melted cores for oxygen isotope analysis. This analysis is being undertaken by the fractionation process applied in a laboratory at the University of Chicago. It is anticipated that useful information can be obtained on the problem of preferential distribution of isotopes of oxygen as a function of latitude.

All core samples from the firn (to the 120-ft. depth) were melted and the resulting water, except for the minor amount necessary for the chemical analyses, decanted for analysis of the stratigraphic concentration of pollen. It was hoped that in this way significant pollen could be found for the determination of annual horizons. Unfortunately, the bore hole diameter and the resulting sample size were too small for significant quantities of organic material and aeolian dust to be collected.

4. Englacial Temperature Measurements

Holes Nos. 2 and 3 (Fig. 4b) were primarily drilled for the purpose of implanting a series of resistance thermometers for subsequent measurement of internal temperatures. This especially concerned the englacial thermal regime as influenced by atmospheric changes.

The temperature measuring equipment was provided by the U.S.Geological Survey and consisted of a set of spaced thermistor cables similar to those used by the Geological Survey in connection with permafrost investigations at Point Barrow, Alaska. The thermistors embodied in the vulcanized cables are manufactured by the Western Electric Company (Type 17A). They consist of small discs of sintered manganese and nickel oxide. The discs are 0.2 in. in diameter and 0.04 in. thick. To each is secured an axial copper lead, (of 0.02 in. diameter), attached with an intermediary spot of ceramic silver paste. The paste is sputtered onto each face of the thermistor disc and the leads are soldered to the silver facing by means of silver eutectic solder. The resulting alloyed semi-conductor provides a 4.4 per cent negative change in electrical resistance per degree change in temperature (Centigrade). Measurements can be made to 0.01°C. by means of an appropriate Wheatstone Bridge.

Cables Nos. 148, 150, and 152 were installed for englacial measurements in 1950. A 200-ft. cable (No. 152) with 18 thermistors, spaced 10 ft. apart for the first 160 ft. and 20 ft. apart for the lower 40 ft., was installed in Bore Hole No. 3. The cable and units were firmly packed in snow which was held in by sheets of rolled paper lightly tied with string. This was deemed advisable to prevent circulation in the hole where air spaces might otherwise occur. Only the lower 157 ft. (10 thermistors) of this cable were implanted in the glacier; the upper 30 ft. (8 thermistors) were left attached to an aluminum marker tower above the surface. The purpose of this cable was to measure englacial temperatures with special reference to the lower limit of penetration of the annual winter chill wave.

A 35-ft. cable (No. 148), with 19 individual thermistors, was located in the upper part of Bore Hole No. 2, with 12 ft. (5 thermistors) extending below the level of the wooden drill platform. The purpose of this cable was to provide supplementary measurements of the diurnal and short-term variations in firn temperature during the winter expedition, 1951. This was of interest especially in regard to the 10 ft. of 1948-49 firn resting below the late summer 1950 ablation level and also for whatever depth of winter snow would accumulate between the date of installation and February 1951.

It should be noted that the aluminum pipe in Bore Hole No. 1 was respectively 5.0 ft. and 6.7 ft. away from Bore Holes No. 2 and No. 3. The influence of metal in the pipe on the temperature of the surrounding ice at these distances is considered to be negligible.

Cable No. 150, a 50-ft. string with nine thermistors spaced 5 ft. apart for the first 40 ft. and the last two 10 ft. apart, was placed in a narrow crevasse below Tower B (see Fig. 4a) at Camp 10B. The three top units were above the 1950 ablation surface; the remaining cable extended vertically into the crevasse. Each thermistor was packed into the crevasse as tightly as possible with shovelled snow to reduce the effects of free air circulation. The lowest two thermistors were thus left in positions 20 and 30 ft. below the 1950 ablation surface in order to provide temperature records supplementary to those from the bore holes.

No measurements were taken with the englacial cables in this summer season since by other means(see Section IX B,3) it was shown that the glacier remained isothermal until the third week of September. Subsequent readings have been carried out in February 1951, in June 1951 and again in June, 1952. Some of the results of these measurements and their partial analyses are presented in the reports of the 1951 expeditions (Miller, M.M. 1953 & in press). Several other sets of cables (Nos. 149, 151, and 153) were left at the research station for use in subsequent field seasons. The reliability and drift characteristics of the thermistors as affected by time are also discussed in the reports of the 1951 expeditions, and, in addition, a listing of the thermistor resistances and a description of the individual spacing of each unit on all cables used in these measurements are given. For purposes of checking and future evaluation of records, a conversion table is available at the Department of Exploration and Field Research at the American Geographical Society in New York City.

5. The Installation and Use of Thermoplastic Thermistor Cables in Glaciothermal Investigations

Thermistor cables of the type employed in the Taku Glacier studies should be installed, if possible, when the air temperature is above freezing. At negative temperatures, which are typical of the ice field in winter or spring, the thermoplastic insulation becomes brittle. At such times, great care must be exercised so that it does not become cracked or shattered by sudden blows or careless flexing.

Even under summer conditions, when temperatures are normally at or above freezing, more than ordinary care should be taken to avoid damage. This is particularly important since it is difficult to make repairs in the field. Non-vulcanized seals or patches are not satisfactory since they have little, if any, adhesion in the cold and are almost certain to leak, especially if placed in a hole filled with water which is under much hydrostatic pressure.

If field repairs are necessary, the following method is recommended. Clean the damaged part for about six inches beyond the break on either side. For sealing, use a vinylite tape, (Scotch Tape No.33). Warm both tape and cable before application and stretch the tape during application as it is wound around the break. The tape should be spiralled and half-lapped across the break to a point about one inch beyond it on the other side. A second layer should then be applied beginning and ending an inch beyond the first on either side. This should be followed by 3 to 5 more layers, each overlapping the previous ones an inch on either side.

It should be possible ordinarily to feed the cable into the hole by hand. It may help to put a small lead weight on the leading end to keep it straight and to aid in feeding into the drill hole. If the cable is bored into the glacier behind a thermal "hot point" bore tip, the bore head will provide sufficient weight. In either case, the cable must be lowered very slowly and carefully to avoid slacking and to prevent snarls which may cause serious damage to the equipment and so jam the hole that the cable cannot be removed. After the cable is fully lowered, wooden clamps should be attached to support it at the top of the hole until it becomes locked in place either by subsequent closing of the hole or by freezing in.

For lowering the cable, simple equipment is required. There are four requisites: a reel on which the cable is wound; a pipe to serve as an axle for the reel; some boxes on which to mount the pipe; and a roll of strong paper and string for wrapping a covering of snow around the cable to reduce air circulation in the hole. For packing the top of the hole, a few pounds of rock wool are helpful; otherwise, it should be filled with an adequate quantity of well-packed snow.

IX. METEOROLOGY

The meteorological program in this season consisted primarily of the record of standard observations at three ice field camps. The data were obtained for correlation with records at Juneau, Annex Creek and other nearby low level stations. Since the objective was to supplement the project's 1948 and 1949 summer observations for the long-range analyses of the ice field's climate, no detailed interpretations are attempted in this report. The weather observing program however is described in the following pages.

A. Routine Weather Observations

A staff of three meteorologists participated in the program throughout the summer. N. E. Turner was in charge of the meteorological program during June and July. After he left, F. A. Milan was the responsible meteorologist during August and September and had the special responsibility of maintaining routine observations at Camp 10. This also involved the morning, noon, and evening relay of weather data by radio to the U. S. Weather Bureau Station at the Juneau Airport. C. O. Harrington kept records at Camp 10B during August and September and Sgt. C. Anderson was responsible at 10B during July and for the records at Camp 16 during August. A summary of the observations is given in Appendices K through O. The 1950 synoptic stations, their dates of record, and other pertinent notes are given below.

Station	Elevation and Location	Weather Records	Remarks
Camp 10	3862 ft., on nunatak adjacent to and 300 ft. above Taku Névé	June 23 - Sept.29	3-hourly synoptics 6-hourly max.-min. continuous thermograph & barograph records
Camp 10B	3575 ft., on Taku Névé	July 1 - Sept.12	3-hourly synoptics and a few micro-meteorological observations
Camp 16	4300 ft., on nunatak in névé of Lemon Glacier	July 15 - 23 Aug. 9 - 16	3-hourly synoptics
Annex Creek	On north shore of Taku Inlet	June - Sept.	Temperature and precipitation records throughout the year
Juneau (U.S.W.B.)	24 ft., Airport Station	June - Sept.	All data throughout the year plus radiosonde and pibal observations

The equipment employed at the ice field camps was of standard U. S. Army Signal Corps and U. S. Weather Bureau type. It was largely the same as that utilized by the 1949 expedition, details of which are available for reference in the Project files. The observing procedures were those employed by the U. S. Weather Bureau and the Air Weather Service. Because there were electrical facilities only at Camp 10, the methods were largely of manual field type. The U. S. Weather Bureau's Manual of Surface Observations, WBAN, Circular N, 6th Edition of January 1947, was used as a procedural handbook.

B. Other Observations and Objectives

In addition to routine climatological records, an effort was made at the glacier camp (10B) to make a few observations of direct glacio-meteorological application. Although no detailed micro-meteorological program was instituted, with the help of the meteorologist at 10B some observations pertaining to the following studies were attempted. It was hoped that the information obtained would also provide a background for planning more comprehensive investigations along these lines.

1. Surface Wind Observations

The structure of local winds on the surface of the Taku Glacier was observed to be of a very marked laminar nature. Even at low velocities, this was readily demonstrated by the behavior of smoke bombs discharged on the glacier air strip during periods of aircraft operation. The average height of the zone of katabatic flow at a velocity of five miles per hour was 3 to 5 ft. Strong katabatic winds were often observed at Camp 10B when no air flow was recorded at Camp 10, which is nearly 300 ft. higher and directly adjacent to the glacier. At other times a west or northwest local glacier wind was noted at 10B while easterly or southerly regional flow was observed at Camp 10. Similar variations are apparent in the comparison of records from Camp 16 and from the surface and upper air at the Juneau Airport. These differences in prevailing winds are shown in the appended meteorological summaries. An example of pertinent records covering three to twenty-four hour periods at the several observation sites are noted in Table IX. On occasions, Camp 16 was affected by regional air flow from the south and southeast while the interior ice field stations, Camps 10B and 10, were not.

Each of the ice field stations is subject to local glacier wind except Camp 10 which usually lies well above the layer of katabatic air flow. The Juneau Airport Station lies five miles south of the Mendenhall Glacier terminus and at times when there is not a strong regional low-level wind it is also affected by katabatic drainage from the Mendenhall Glacier. However, since the airport lies on an exposed plain at one end of the southeasterly trending Gastineau Channel, it is readily affected by the southeasterly winds which are characteristic of most severe summer storms along this coast. This station is also in a relatively unobstructed position as far as winds from the northwest and west are concerned (Fig. 2).

In Table IX, those days in which regional air flow was clearly dominant over local katabatic wind are noted by (R). In cases where katabatic influence was dominant, the values are designated by (K). In all other cases, it appears that divergent effects were the result of changing regional conditions affecting the weather at the different camps at different times. In any comparison of short term meteorological records between these sites, it is obvious that a number of complicating considerations must be kept in mind.

The three-hourly comparisons in Part B of Table IX are taken from three days in July when local glacier winds were the controlling factor in the weather at Station 10B. During this period at Camp 16, katabatic conditions prevailed only on July 22nd with regional flow being the overriding factor on the 21st and 23rd. The regional winds, as in this case, were usually stronger and steadier whereas local down-glacier drainage of cold air had a marked diurnal fluctuation.

Table IX

MIDSUMMER WIND DIRECTION AND VELOCITY RELATIONSHIPS AT FOUR STATIONS ON AND ADJACENT TO THE JUNEAU ICE FIELD

A. Comparison of Daily Averages, Mid-July and Mid-August, 1950

	Juneau Airport Station		Mendenhall Gl.Terminus		Camp 16 Lemon Gl.Névé	
Date 1950	Highest Velocity (mph)	Upper Air Velocity (4000')	Prevailing Direction	Prevailing Upper Air Direction (4000')	Average Velocity (mph)	Prevailing Direction
July		Avg.				
15	11 (E)	10	N (K)	SE	5.2	SE (R)
16	19	25	ESE (R)	SE	16.0	E (R)
17	20	20	E (R)	SSE	14.5	E (R)
18	17 (SE)	10	N (K)	SSE	5.2	E (R)
19	17	10	E	S	9.3	SW (R)
20	16	17	E (R)	SE	9.2	SE (R)
21	12	12	WSW (R)	E	12.5	NNE(R)
22	13	12	ESE (R)	E	11.3	N (K)
23	17	12	E (R)	SE	21.7	SE (R)
August						
9	15	12	N (R)	ENE	20.0	NE(R)
10	8	10	N (R)	NNW	2.0	NNW(R)
11	16	10	E (K)	NNW	8.0	N (R)
12	16	10	E (R)	SE*	1.7	SW(R)
13	8	10	N (K)	SE*	4.8	NE(K)
14	14	10	N (R)	ENE*	23.3	N (R)
15	11	12	E (K)	NNE	7.7	N (R)
16	10	12	SE (R)	SW	5.5	S (R)

Note: *Indicates direction variable from N. to SE.
Underlined values estimated from Yakutat and Whitehorse pibal records.
Balloon runs taken at 6-hourly intervals each day beginning at 0100 PST.

Table IX

A. Comparison of Daily Averages, Mid-July and Mid-August, 1950 (continued)

Date 1950	Camp 10B Taku Gl. Névé: Average Velocity (mph)	Camp 10B Taku Gl. Névé: Prevailing Direction	Camp 10 Taku Gl. Nunatak: Prevailing Direction
July			
15	4.0	W (K)	E (R)
16	2.6	WSW	E (R)
17	3.1	E (R)	E (R)
18	3.5	W (K)	E (R)
19	2.1	W (K)	E
20	2.1	W (K)	E (R)
21	4.0	W (R)	W (R)
22	10.8	W (K)	SW
23	5.8	W (K)	E (R)
August			
9	5.0	W (K)	N (R)
10	-	-	NE (R)
11	7.8	W (K)	NE (R)
12	2.3	NW (K)	E (R)
13	-	-	E (R)
14	8.5	N (R)	W
15	3.7	NW (R)	N (R)
16	3.4	NW (K)	NE

B. Comparison of Three-hourly Readings July 21-23, 1950

Date & Hour	Juneau Airport: Wind Dir.	Juneau Airport: Maximum Velocity	Upper Air, 4000 ft. Over Juneau Airport: Direction & Velocity	Camp 16: Wind Dir.	Camp 16: Vel.	Camp 10B: Wind Dir.	Camp 10B: Vel.	Camp 10: Wind Dir.	Camp 10: Vel.
July 21									
0700	N	1	SE 15	NW	8	W	8	WNW	3
1000	WSW	2	-	N	10	W	7	NE	2
1300	WSW	4	E 10	NE	15	W	10	S	4
1600	WSW	10	-	NE	15	W	5	W	5
1900	WSW	5	E 10	NNE	15	W	13	W	3
2200	N	3	-	NNE	12	W	15 +	W	3
July 22									
0700	Calm		SE 10	N	12	W	10	N	1
1000	SSW	3	-	N	10	W	7	S	1
1300	SW	8	E 10	N	15	W	4	SW	1
1600	ESE	4	-	E	4	W	15+	SW	2
1900	ESE	6	ENE10	E	5	W	4	E	4
2200	SSW	3	-	E	22	W	5	W	1
July 23									
0700	ESE	10	SE 15	SE	20	W	4	ENE	4
1000	Calm		-	SE	25	N	2	E	12
1300	ESE	8	S 15*	E	30	E	2	SE	8
1600	ESE	8	-	SE	20	NW	2	E	4
1900	E	8	S 10*	SE	20	W	5	E	4
2200	ESE	17	-	E	15	NNW	2	E	6

*Observations not possible at Juneau Airport due to low ceiling; values therefore estimated from Yakutat and Whitehorse pibal records.

At 2000 on July 22nd at 10B, the wind was West at 5 mph. at the névé surface; but at the top of the 43-ft. instrument tower it was blowing from the North at 10 mph.

The vertical distribution of velocities and related factors in the katabatic air layer at the névé surface are suggested by the following record from the instrument mast at Camp 10B for one evening in mid-summer.

Table X

VARIATIONS IN THE KATABATIC WIND PROFILE
TO A HEIGHT OF 300 FEET ABOVE THE TAKU GLACIER NÉVÉ

Date & Hour July 21, 1950	Height Above Névé (feet)	Wind Direction	Wind Velocity (mph)	Air Temp. (°F.)
1800	0.5	W	-	37.0
1815	0.5	W	4.8	37.0
1845	0.5	W	3.0	-
1800	4	W	-	39.4
1815	4	W	7.6	38.5
1845	4	W	11.0	38.5
1900	4	W	-	38.4
1800	10	W	-	-
1815	10	W	12.0	-
1845	10	W	11.3	-
1900	10	W	13.0	-
1845	21	W	11.3+	-
1845	33-36	W	11.2	-
1815	300*	W	3	58.0
1845	300	W	-	56.3
1900	300	W	3	55.5

*Camp 10 record, at site of anemometer mast, 13 ft. above level of Station 19.

2. Thermal Variations in the Katabatic Air Layer

A comparative record of temperature changes at selected levels in the katabatic air layer at Camp 10B was obtained in mid-summer. One micro-thermograph was placed in an instrument shelter four ft. above the névé and a second one on the instrument mast at a point 36 ft. above the névé. Hourly variations in temperature as recorded by these instruments are listed in Appendix P. These temperatures were obtained over the following periods.

Micro-thermograph at 4 ft. (instrument shelter)	Micro-thermograph at 36 ft. (instrument mast)
July 16 to 31 inclusive	July 25 to 31 inclusive
August 1 to 31	August 1 to 12; August 14 to 21

In addition a brief record of thermal variations at several intermediate elevations between the surface and 36 ft. was obtained by use of thermistors. These measurements, however, were restricted to evening and night-time readings since it was believed that direct sky and solar radiation effects could not be fully eliminated. To minimize the effects of radiation, sheets of tinned metal were wrapped around each thermistor at a 5-in. diameter leaving a 2- to 3-in. air space for aspiration. The purpose of these measurements was to provide a test for future instrumentation and planning of detailed investigations of the thermal relationships involved. The resulting records, however, are not considered to be reliable because of the relatively large mass of the protective rubber casing which tended to smooth out the curves. It is recommended that future measurements of this type be made with shielded copper-constantan thermocouples properly aspirated with a blower tube and fan.

3. Summer Firn Temperatures

For englacial temperature readings, a series of thermistors was installed to a depth of 170 ft., as noted in Section VIII-C. Readings were not made on these in September. However, temperature conditions at the deeper levels were considered to be still isothermal up to the date of evacuation of the field party. In the last ten days of September, the upper one to two ft. of firn became frozen, representing onset of the annual winter cold wave.

To test mid-summer temperatures in the firn, a micro-thermograph was buried in a crevasse wall, 33 ft. below the surface at the base of Pit C. A record was obtained for the 24 hours between 1230 on July 18th and 1230 on July 19th. The thermograph was in direct contact with undisturbed firn. The resultant trace on the record sheet was constantly at 32°F., showing no diurnal fluctuation. Atmospheric conditions were more or less constant during this period, being foggy at the surface with ambient air temperatures averaging 39.3°F. (from a maximum of 45° F. to a minimum of 32°F.). At 1300 on July 19th, a recording thermograph was also installed in a wall recess at the 6-ft. depth in Pit A, which was thereafter completely filled in to eliminate contamination of the thermal record by surface air variations. A 24-hour record at this location likewise produced a straight line (32°F.) trace on the thermograph sheet. Variation in ambient air temperature during this period was from a minimum of 31°F. to a maximum of 46°F. This corroborated the other observation at the deeper level that atmospheric influences were negligible and that the firn was isothermal at this elevation. Subsequent checks showed this condition to prevail throughout the summer.

Some short-term negative temperature effects, however, were observed in the upper one- to two-in. surface layer of the firn. These were indicated by the occasional development of diurnal surface crusts. At Camp 10B from June 23rd to September 3rd, seven nights were reported during which good crusts were developed. They were therefore not a significant characteristic of the summer firn below the 3600-ft. elevation. The amount of night-time ablation has already been discussed earlier in this report and noted in Fig. 5. The crusts were much less frequent in this summer than at the same elevation in the summer of 1949. This fact probably relates to the abnormally severe ablation conditions encountered in this field season. Observed crusts were developed only on nights with a prevailing north or northwest and very occasionally a west wind. These were usually the katabatic winds and not related to regional flow. There were usually corresponding clear skies with the thickest crusts occurring on the clearest nights. Sub-freezing temperature of the free air which is directly in contact with the névé surface will certainly help to develop a crust. In this regard, katabatic drainage of cold air from the higher névés of the ice field at night can be a contributory cause. The field observations, however, indicate that occassionally a crust may form when the overnight temperature in the air layer at and above four ft. above the surface (see below) is some degrees above freezing. Thus, heat loss from the firn by nocturnal radiation on many occasions is the prime factor in the development of crusts. In this season, the crusts usually began to form about 2100, although on several occasions not until after midnight. On one night, the crust formed as early as 1800 and persisted until 1100 the next day. In most cases, they were destroyed between 0700 and 1000 the following morning. Not until the last half of September were crusts persistent throughout one day to the next.

The observed relationships are noted briefly in the following tabulation.

Date 1950 (night)	Hour of Crust Formation	Approx. Thickness of Crust (in.)	Wind Dir. and Velocity	Average Cloud Cover (tenths)	Minimum Overnight Ambient Temperature at 4-ft. Height (°F.)
July 3-4	2000	3/4	NW 10	4	32.5
4-5	2200	1/4	NW 3	9	35.2
7-8	1800	1	NW 7	4	29.0
8-9	2100	1/2	N 5	7	40.1
9-10	a.m. of 10th	1/8	NNW to WNW 3 to 8	8	36.1
10-11	2100	1/4	NNW 4	8	33.3
14-15	a.m. of 15th	very slight	W 6	10	33.4
August	No diurnal crusts reported				
September	No crusts observed until ablation season ended with fresh snowfall of September 3-4. During last week of September, 12 to 24 in. of firn surface became solidly frozen.				

C. General Climatological Conditions

The temperatures as reported at the Juneau Airport in May were lower than normal, a situation which had prevailed since the previous November. This indicated a colder than normal winter condition on the ice field as well. May, on the whole, was an abnormally cloudy month with more than average rainfall. On the ice field, this likely represented above normal late spring snows. The month of June throughout Southeastern Alaska was much more sunny and warmer and drier than normal. In fact, at the Juneau Airport the amount of sunshine was the highest on record in the eight years that this station has been in operation. The average monthly temperature was within 0.4 degree (F.) of the maximum on record (1946). The total precipitation in June was well below normal and equalled the lowest on record (also 1946). Since the ice field party did not commence its records until June 23rd, only the last week is available for comparison. Undoubtedly, however, as in Juneau, this was the cloudiest week of the month. From the 23rd to the 30th, there was approximately the same amount of precipitation recorded at Camp 10 as at the Juneau Airport.

In July, the airport temperature was above normal in the first 10 days and then subnormal in the latter three weeks of record. The date of lowest temperature recorded at the airport, July 8th, was also one of the two days, July 8th and 27th, of lowest record at Camp 10. An above average precipitation was recorded at Juneau, 7.07 in., being exceeded only by the recorded 7.71 in. in July 1945. This was the result of rain every day during July with the exception of July 1st, 4th and 8th. On the average, it was drier at Camp 10 with a total of 6.95 in. of rain. At Camp 10B, 8.01 in. of precipitation were recorded, the difference being attributed to the light rains often associated with fog on the glacier surface. At Camps 10 and 10B, the sky was almost continually overcast during this month with rain falling every day except July 1st, 4th, 8th, 9th, 10th, and 11th. Some comparative July and August precipitation data are listed below for the five synoptic stations on and near the ice field. Values are in inches of water.

Date (1950)	Juneau Airport (24 ft.)	Annex Creek (20 ft.)	Camp 16 (4300 ft.)	Camp 10B (3575 ft.)	Camp 10 (3862 ft.)
July 15 to 25 inclus.	4.09	4.43	4.17+	3.71	3.13
August 9 to 16 inclus.	0.09+	----	Trace	0	0.02

In August, the airport temperatures were above average with the first half of the month being very dry. Rain fell in the last half to bring the monthly total to 4.95 in., which was 0.23 in. above normal. At Camp 10, the total precipitation for August was 8.3 in., nearly twice as much as at Juneau. At 10B, the recorded total was 11.17 in. of water which again may be attributed to the fact that this site was situated directly on the glacier surface where condensation under certain conditions could be relatively greater. The storm which caused heavy rain at Camp 10 in the last week of this month brought heavy falls of snow at all elevations on the ice field above 5000 ft., some of which formed the first increment of the 1950-51 winter snow cover.

The month of September was above average in rainfall and temperature conditions both at the low level sites and on the ice field. At Juneau, an average amount of cloudiness for this time of year was recorded. The total precipitation at the airport was 7.34 in. while at Camp 10 a total of 13.6 in.

was recorded--some of which was in the form of heavy wet snow. Sub-freezing temperatures occurred at Camp 10 after September 20th on which date the winter cold wave may be assumed to have begun its annual penetration of the glacier surface at the 3500- to 4000-ft. level. Sub-freezing conditions had also prevailed for a few days during the first week of September at Camps 10 and 10B. However, a warm period with increased sunshine in the middle of the month probably succeeded in dissipating the preliminary chill effect in the firn prior to the 20th. The first killing frost of autumn occurred at the Juneau Airport on the morning of September 30th.

Throughout the area, October was cool and dry with precipitation and temperatures very much below normal. Average October rainfall at Juneau Airport on all previous years since 1942 was 8.32 in. of water. For this month in 1950, however, only 2.71 in. were recorded. Since the mean temperature at Juneau was 38.9°F. for this month, the normal lapse rate to the 4000-ft. level indicates that temperatures averaged somewhat below freezing at Camps 10 and 10B throughout most of this period.

In the listed appendices, in addition to the June through September summaries for Juneau and the ice field camps, the temperature and precipitation records from Annex Creek Station are included. In order to provide continuity with the winter meteorological data in the report of the winter 1951 expedition, the Juneau Airport data for October, November and December 1950 are also included in the appendices. These are data from the three intermediate months between expeditions when Camp 10 was not occupied. Thus, summary data are made available for the full 18-month period between May, 1950 and December, 1951.

D. Duration of Sunshine

For interpretation of the summer sunshine records obtained at Camp 10 and contemporaneously at the Juneau Airport, certain necessary technical considerations are described in the reports of the 1951 summer and winter expeditions. Of very great importance to these analyses is the listing of the vertical angles of obstruction versus azimuth at the observation site which are given in Appendix R . From these, the amount of possible sunshine cut off by the obstruction may be determined for each month of the year. This factor can then be deducted from the total possible sunshine for the month. The duration of sunshine records for Camp 10, covering the full field season from June 23rd to September 28th, are given in Appendix K . Appendix Q contains the listing of possible duration of sunshine at Juneau Airport for each day of the year.

The duration of recorded sunshine is not the record of hours of sun seen by the eye, but only of periods when the sunshine was of sufficient intensity to scorch the card. At times when the sun is bright but intermittent, the trace may be nearly as long for a few seconds as it is for a few minutes. This is due to the appreciable diameter of the image and to the smoldering of the card. Near sundown or sunrise when sunlight is passing through a haze, the card may be only faintly burned. In this case, the whole of the faint trace should be measured to its extreme limits. To achieve uniformity in measuring, the suggestions for evaluation which are given in the 1951 project reports should be followed. Only in this way, can the comparison of results from one field season to the next have proper meaning.

E. Solar And Sky Radiation Records

With the aid of an Eppley 50-junction pyrheliometer and an accessory Brown recorder loaned by the U. S. Weather Bureau, eight weeks of record were obtained of total sky and solar radiation at the Camp 10 site. Because of mechanical difficulty with the generator equipment which supplied power to the recording unit, some hours and days of record were unfortunately lost. This situation was recognized in the field and therefore in the following summer season a more reliable heavy-duty generator was installed at Camp 10. Consequently, the 1951 summer records had the benefit of a more steady and reliable source of power and thus they are more useful for comparative interpretation. Both pyrheliometer records are listed in Appendix S, .(see also Fig. 16a).

All readings are given in langleys, which indicate the radiation in gram-calories per square centimeter of horizontal surface. The values are for the hour ending at the time shown at the top of each column. The records and integrator calibration data and other evaluation factors are given in <u>J.I.R.P. Report No. 8.</u>

The periods of radiation records which have been obtained to date are as follows:

<u>Camp 10</u>: Lat. 58° 39' N. <u>Elevation</u>: 3862 ft.	July 8 to September 13, 1950 September 4 to 6, 1950 September 11 to 13, 1950 February 12 to 14, 1951 August 24 to September 2, 1951
<u>Camp 10B:</u> one mile S.W.of Camp 10 <u>Elevation</u>: 3575 ft.	September 7 to 13, 1951

Resolution of the basic recorder chart data into langleys per hour has been accomplished with the help of Mr. Edward Sable of the U. S. Weather Bureau's Solar Radiation Field Testing Station at Boston, Massachusetts. He reported that evaluation of some of the records was rendered difficult because of an occasional stalling of the paper drive on the recorder. In the 1950 records, the stalling was indicated by an abnormal concentration of ink markings from the recorder pen on the zero line. In these cases, due to the resultant distortion of timing, no attempt has been made to evaluate the record. Some distortion of timing was also evident at other times as a result of the irregularity in power supply. In these records, whenever such distortion was detected, the noon hour (solar time) was noted by folding the chart or by using the highest point on a trace of the smooth curve. From this reference the hours of the day were marked on the charts. It should be mentioned that the daily records obtained during the 1950 field season were often started at or somewhat after sunrise and similarly stopped at or before sunset so that there is not a continuous record of twilight hours.

The records from the following summer (1951) are short but are more accurate. The chart record prior to September 3, 1951, is considerably more reliable than that after September 4th since the equipment was moved to Camp 10B on that date, where the power supply was less satisfactory than at Camp 10. Time markings entered on the chart several times a day were of much help in measuring average hourly values from the recorder trace.

X. GEOLOGICAL INVESTIGATIONS

Some reconnaissance studies were carried forward in this season concerning the geomorphology and bedrock geology of the ice field and its adjacent, recently deglaciated, area. This work was conducted primarily to provide a few basic data for a continuing study and to outline a program of future detailed investigations along these lines.

A. Aerial Observations of Physiographic Features

Since the inception of this project, observations of considerable use to the research program have been made on a number of flights over the ice field. The value of these observations has been enhanced by later studies of the aerial photographic record obtained. In this season, for example, the locations of Camps 15 and 8 were thus planned and the best routes of approach to other locations were reconnoitered for use in this and subsequent seasons.

The series of aerial photographs taken over the ice field in 1948, especially the vertical coverage by the U. S. Navy, has proved of particular value both in logistic planning and in the scientific study of certain glacio-morphologic features. To supplement this record and as an aid to implementing future ground work, a number of oblique aerial photographs were obtained by several members of the field party in 1949 and 1950. Additional pertinent photographs have also been taken during flights by private aircraft in the 1951 summer season.

A special effort was made in 1950 to obtain low-level oblique aerial photographs of the following: (1) Ice-dammed lakes: on and near the ice field. (A preliminary discussion of the nature and apparent drainage fluctuations from some of these lakes has been given in J.I.R.P. Report No. 6.) Two previously unreported ice-dammed lakes of considerable size were noted from the air on the northeastern side of the ice field. An eventual physiographic ground study of these is planned. (2) Arched bands: additional photographs were taken of the pattern of "arched bands" and related trough and ridge topography below the ice fall on the outlet glacier from the upper Taku Glacier névé three miles west of Camp 8. These were obtained for the purpose of special investigations at this site. Photographs were also taken of representative examples of "stratification bands" to differentiate them graphically from true "arched bands". Additional photographs of two strikingly banded glaciers in the Camp 15 sector will also help in planning future work in that locality. (3) Marine bench strand lines: Aerial photographs were obtained to supplement certain ground observations in the Taku Valley and Juneau sectors. (4) Transient snow lines: Observations and photographs were made on the changing position of the transient snow lines of several glaciers at various times during the season. (5) Glacier termini: The positions of the termini of a number of glaciers were photographed. (6) Scour line: Further aerial records and estimates were made of the relative height of the 200- to 300-year old scour and trim lines at various places on the ice field.

B. Problems in Nunatak Morphology

In the central portion of the ice field, several large nunataks have resulted from partial deglaciation since the last "ice cap" stage of the Pleistocene Epoch. Many of these were individual mountains or ranges once nearly (or completely) overridden by ice and thereby characterized by convex ridge-tops and rounded summits as well as scoured and fretted upland slopes. Although the resulting glacial topography has been superimposed on an earlier non-glacial morphology, much of the original character of the landscape has been destroyed. Trunk valleys, still partly filled with interconnected branches of existing glaciers, were initially formed as water courses in pre-glacial time and have suffered excessive erosion and modification by successive glacier stages. It is possible on many of the higher nunatak slopes to differentiate the influence which older "ice cap" glaciation has exerted in comparison with that of subsequent "alpine" glacier stages.

Very few large-scale depositional features exist in the highland. The morphology of present-day nunataks is essentially one of smooth and scoured bedrock with little or no vegetation cover. On a traverse from the periphery to the center of the ice field, all stages of the cycle of alpine cirquation may be observed. These extend from the area of partial and shallow development of cirques on a broadly uplifted pre-glacial surface at the margins to a monumental upland on the present ice field where comb ridges, pyramidal spires, ill-formed horns, cols and other typical alpine mountain features protrude above the existing glaciers. The first mentioned might be termed a youthful alpine landscape; the latter, an end stage, or old age. Between these two extremes, is a range of glacial topography which in the classical sense may be considered an ice-sculptured terrain of maturity. This zone is characterized by portions of the uplifted pre-glacial surface retained in gentle divides and cols with a system of cirques alternated in position on each side of ridges to form a typical "biscuit board" topography.

Comparative study of these landscape types throughout the area is envisioned. During the 1950 season, however, efforts were put forth only to conduct a reconnaissance investigation of the "late mature" glacial landscape on several nunataks in the Camp 10 sector near the center of the present ice-covered area. For reference purposes in the following notes, these are termed the "central nunataks".

The symetrical form of once-overridden nunataks is often the best evidence for the general direction of former ice movement. Many of the nunataks exhibit, on a major scale, the lee and stoss sides commonly associated with "roches moutonneés". By virtue of subsequent local glacier action, the initial erosive form has occasionally been modified to a "reverse horn" topography. Norris Peak and Juncture Peak (Fig. 3) are good examples since each has suffered undercutting on the up-valley flank by headward erosion of cirque and inter-nunatak basin glaciers which by their northern exposure have persisted in a state of relative nourishment. Most nunataks in the area have also been subjected to over-steepening at the base of slopes through continuous glacial abrasion of adjacent valley glaciers. In such ways, the successive stages of glaciation and deglaciation have considerably modified the terrain and complicated the interpretation of bedrock morphology.

For detailed studies of the meaning of this landscape, one fortunately has recourse to certain useful criteria given by microstructures and related features on the bedrock surfaces. Because there is a variety of lithologies exposed in the geological complex of this ice field, practically all manifestations of glacial surface features which have been described in the literature may be seen. Their manner of occurrence can often be used to interpret the effects and extent of former ice coverage. The criteria used in this way are: (1) grooves, (2) striations, (3) friction marks (crescentic gouges or lunoidal furrows), (4) chatter marks, (5) surface polish, (6) rock flour (as a surface veneer), (7) iron oxide stains and incrustations (8) kaolinized surfaces, (9) scaled, spalled and pitted surfaces, (10) granular disintegration, (11) felsenmeer topography, (12) soil types and (13) vegetation.

The distribution study of these features throughout the ice field is a tedious and time-consuming one. Thus, several field seasons of work will be required to plot and assess fully the significance of their over-all pattern. The general nature of their distribution, however, has already become clear. For example, striae are not as well shown in coarse-textured rock as in the finer-grained types, especially the aphanitic intrusions such as the leucophyres and lamprophyres of Tertiary age. (See J.I.R.P. Report No. 1, page 43.) Grooving is mostly characteristic of older glaciation and is best shown in the bedrock outcrops characterized by stoss and lee topography. Friction marks are best developed on slopes of low gradient. They are helpful for the determination of former directions of ice passage over coarse-grained outcrops where the more elongated furrows and striae have been weathered away. Each of these oriented criteria only indicates the line of glacier movement, but usually the true direction of glacier flow can be assessed.

Friction marks are found most often to be convex in the direction of former ice flow although the reverse orientation has been observed. It is best to take the line as parallel to the axis of the crescent and to evaluate the compass direction of glacier flow from the regional topography. Chatter marks are not in themselves useful for evaluating directions of ice transfer; however, their presence in any abundance probably indicates a fairly thick glacial coverage at the time of formation. The degree of disintegration and removal of portions of polished surfaces is a helpful key to the relative age of one zone to another. In special instances, the presence of rock flour and of alteration products by chemical decomposition may also be used as indicators as may the nature of surface products from combined chemical and mechanical weathering. Correlated with these, a study of soil development and the related plant community on an outcrop can give further valuable information.

In the following pages, a brief discussion of the field aspects of these several criteria is presented.

1. Direction of Former Glacier Flow

On the central nunataks, an abundance of glacial striae and grooved and polished surfaces may be found. On "Taku B", for instance, several prominent directional patterns of striae occur. In some cases one set of striae is superimposed on and even truncates an earlier and more deeply grooved set. One direction relates to recent "local" glaciation and one to the regional Pleistocene "ice cap" glaciation. Near the summit of this nunatak, at an elevation of about 4900 ft., are found strongly developed striae trending 188 degrees and 192 degrees (True). The Taku Glacier near the base of this nunatak now flows in a southeasterly direction (approximately 150° True). By projecting the reciprocal direction of these striations, the central source of the related Pleistocene ice cap is indicated to have been in the vicinity of Camp 8 (Fig. 2). Camp 8 is on the highest present-day névé of the ice field, in a crestal sector from which glaciers flow outward in all directions.

In the interpretation of regional directions of former ice movement over and around the central nunataks not all of the striae can be used since they are often oriented by local irregularities of topography. Therefore, in the field, it has been more usual to record only directions indicated on the flattest surfaces, or at least on those of fairly low gradient such as are found in broad cols and on the convex crests of summit ridges.

Records of the direction of Pleistocene ice flow have been noted on several central nunataks bordering the upper Taku Glacier. These locations were on the nunataks known as "Taku A","Taku B", the massif known as "Exploration Peak", and on an adjacent nunatak, "Taku C", about three miles north of Camp 10. The summit of "Exploration Peak" is 5907 ft. in elevation and of "Taku C" 5048 ft. All except "Exploration Peak" have been completely overridden. The morphological character of "Exploration Peak", however, indicates that its upper glaciation limit was somewhere a few feet below the summit. The southwestern, southern and southeastern flanks of this nunatak and of "Taku C", between elevations of 4200 and 5100 ft., yield useful information on the extent and behavior of earlier glaciers. Grooved and striated surfaces on exposed cols and the summit ridges indicate that a major direction of overriding occurred in the direction 200 degrees. Flat portions of bedrock are rare on this massif; however, on a few low gradient slopes there is corroborative evidence, rendered by the presence of crescentic gouges, that the direction of ice passage was towards the southwest. Thus, here the direction of former ice drainage corresponds approximately to that of the present Taku Glacier system towards the west and south.

The level of the 200 to 300 year glacier maximum was measured by micro-altimeter to have reached the 4180-ft. contour on the southern slope of "Taku C". Evidence for this was an irregular but well-defined scour line and a slight topographic break. The present névé surface rests at 4140 ft., indicating that the maximum was 40 to 50 ft. higher than the general glacier surface of today. Actually it was about 100 ft. above the névé in the bottom of a marginal depression at the southern base of this nunatak.

A brief listing of a few locations where surficial marks on bedrock show the former direction of ice movement on the central nunataks is given below. For comparison, the orientation of several sets of striae which were controlled by local topography are also included.

General Location	Approx. Elevation (feet)	Nature of Evidence	Type of Bedrock	Direction of Movement (in degrees, True)
Taku A., W. slope	4-4200	Striae, grooves, friction marks	Granodiorite; Migmatite	215 (ice cap stage)
Taku B, NW flank(10C)	39-4000	Striae	Migmatite	185*
Taku B, cirque, W. flank	4600	Striae	Granodiorite	240*
Taku B, NW ridge	4400	Striae	Migmatite	220
Taku B, high platform, S. ridge	4850	Striae, friction cracks	Granodiorite	188 (ice cap stage)
Taku B, summit area	4950	Striae, grooves	Amphibolite	192 (ice cap stage)
Taku B., S. slope	4600	Friction cracks	Aplite	190 (ice cap stage)
Small nunatak, W. of 10C	37-3800	Striae, roches moutonnées	Migmatite	170*
Slope, SW of Camp 10	3640	Crossed striae	Lamprophyre intrusive	210-215 (ice cap stage) 165-180*
Taku C., E. ridge	4800	Striae	Granodiorite	200
Exploration Peak, SW ridge	5200	Striae, friction cracks	Granodiorite	210
Exploration Peak, S. flank	4175	Striae	Granodiorite	250*

*On recently deglaciated surfaces where ice movement was controlled by local topography or that of recently adjoining trunk glaciers.

2. Weathering Phenomena on Deglaciated Surfaces

In arctic mountain regions, it is usual for processes of mechanical disintegration to be dominant over those of chemical decomposition. This is a result of the relatively greater exposure of bedrock surfaces due to reduced vegetation cover and to low average annual temperatures. In the dominantly maritime climate of the Juneau Ice Field, however, exposure and low mean annual temperature factors are combined with a considerable rainfall during the summer season. Thus, even at high elevations, chemical weathering processes play a more significant role than would be the case in less humid environments.

Efforts have been made to use the degree of weathering as an indicator of the amount of time that a surface has been free of ice. Since chemical weathering on the crystalline bedrock exposures is usually restricted to a very thin surface layer, it has not been possible to draw conclusions from weathering profiles of differential leaching or laterization as has been done in some of the Pleistocene soil and till deposits of more continental origin (See Ashley, 1938, and Reiche, 1945). However, an attempt has been made to differentiate on a purely relative basis, the time of deglaciation on various surfaces by comparison of katamorphic alteration products. The most obvious of these are due to oxidation and hydration at the surface. The oxidation in most cases has not succeeded in completely destroying the parent minerals; from them new ones have been produced by the occurrence of which certain interpretations may be made.

Ferric oxide stain is most difficult as a criteria because we have no information on its rate of formation. Under some conditions, it will develop very slowly and under others, it may become strongly manifested in a fairly short period of time. In general, however, an empirical comparison of the relative degree of oxide weathering on similar exposures of the same lithology is of value. In these cases, the heaviest incrustations are likely to be old, that is if they are found primarily in situ and not washed-down from another outcrop. The relative age of limonite is particularly difficult to evaluate since it does go into solution and can therefore be carried some distance from its source. Whenever the chemical decomposition of the more resistant femag minerals produces stains of ferric oxide (Fe_2O_3), it indicates that the surface has been ice-free for a considerable length of time.

Often an iron oxide stain is observed beneath a veneer of rock flour. It is suggested that the oxide in such instances was formed in a non-ice covered stage prior to the deposition of rock flour and that the most recent glacial action was not sufficiently strong to abrade it completely away. However, some of the oxide incrustations, as already mentioned, are formed by present processes and are being continually washed down over exposures of rock with which it is not normally associated. In this way, the surface beneath a veneer of rock flour could be stained. In many other cases, pronounced hematite staining has been observed on the down-slope side of overridden rock bosses of homogeneous bedrock, in cases where no oxide film is found on the stoss side. From such, we conclude that the stain was most likely pre-glacier coverage and that on the stoss side it has been removed by abrasion. If the stain were entirely produced in a post-ice period, the stoss side would certainly exhibit some stain as well.

A veneer of rock flour is not very resistant to mechanical disintegration. When seen in its exposed state on this ice field, therefore, it is almost certain to be very recent (100 to 200 years). Its occurrence is therefore a fairly good indicator that the surface involved has only recently become ice-free. Together with the larger fragments of rock held in the sole of a glacier, rock flour is one of the abrading agents in any forward-moving ice mass. This fact is well demonstrated by its presence in minute crevices in which fine polishing and rounding, which could not have been produced by the abrasive action of larger fragments, are observed. In many places, the veneer is of differential thickness and fills in glacial grooves and striae including those formed in earlier glacial stages. At a number of places, striae found on the incrustation of rock flour itself diverge in trend from the direction of underlying grooves. This is further field evidence that the ice which deposited the rock flour represents the most recent stage.

On some nunataks in the area, where coarsely crystalline bedrock is exposed, especially the coarse-grained amphibolite, there is often a pronounced development of mechanically weathered rubble and scree. The rubble is actually the product of combined mechanical disintegration and chemical weathering involving internal stresses incurred by differential expansion from the slight hydration of the feldspar constituent (See Blackwelder, 1929). The result is an aggregate of loose crystals and individual grains from the granular disintegration of bedrock in place. During the summer months, decomposition of the feldspars in such a way is facilitated by the considerable rainfall at all elevations on the ice field. During the winter, hydration processes are undoubtedly minimized in the highland due to the negative temperatures which prevail.

Although granular disintegration may operate at lower elevations throughout the year, removal of its weathering product is usually retarded by vegetation. The results are therefore more readily observed on the highland slopes and are especially characteristic of elevations above the level of the 200 to 300 year scour line. In the scour zone, much of the granulated mantle has been stripped away by the recent passage of ice. At some sites, this is a useful indicator of the limit of most recent glacial expansion.

Coincident with breakdown of the feldspar constituent on some outcrops is the formation of colloidal clay through kaolinization. The early stage of this development is often shown by a kaolin enamel. This is considered an indicator of post-glacial surfaces which were probably exposed to atmospheric weathering for several thousands of years; or at least for a lengthy intermediate interval prior to the recent glacial maximum. In most cases, such weathering products post-date the formation of underlying grooves and striae.

Mention is made of the scree patches formed by granular disintegration on the slopes adjacent to and southwest of the research station. Here, the disintegration of granodiorite has proceeded especially well in the main gulleys and subsidiary water courses. In many places, it is associated with a mantle of soil. The presence of soil may be traced down-slope nearly to the glacier's surface. Although no sharp line of differentiation could be observed, due to the mass transfer of loose material under the influence of gravity, it is apparent that a gradation does exist from an upper zone of maximum disintegration at or near the cabin site to one of minimum disintegration a few feet above the present névé to the south and southwest. The advance state of granulation on the ridge-top behind Station 19 (elevation 3862 ft.) is fair evidence that the upper limit of most recent glacial maximum on the slopes of this nunatak was below that contour. In this connection, sets of crossed striations may be observed on outcrops of an ultra-basic dike about 60 ft. above the névé surface of the moat at the edge of the glacier. One set of striae was measured at the 3640-ft. contour which is approximately 50 ft. above the general level of the névé at Camp 10A. From this it is clear that the recent expansion at least reached this elevation on the southwest side of the Camp 10 nunatak. The two dominant directions of striae recorded on this slope are (a) 165 to 180 degrees and (b) 210 to 215 degrees. The former, a much less well-developed set, is considered to have been formed by the recent glacial surge. The other set is deeper and better developed and has an average direction of 212 degrees. It probably represents the direction of flow of an earlier and more prolonged ice-cover. This trend correlates well with the regional direction noted on flat surfaces at upper elevations of the central nunataks. The fact that the more southeasterly direction of striae parallels the present flow of the adjacent local part of the Taku Glacier makes it reasonable to attribute their formation to the 200-300 year advance.

The problem is how high above this level did the recent maximum scour? Since "modern" striations may be found only on occasional outcrops of an aphanitic dike, there is little evidence by which the limit can be exactly determined. On this slope, however, there is a marked increase in granular disintegration at 3700 ft. which suggests that the recent ice limit was below that level. Although plant growth does not give a ready clue to this limit, a study of the development of lichen by a specialist may yield some results.[7] Because vegetation depends on the presence of soil, there is an interrelation, of course, between its occurrence and the breakdown of bedrock. A detailed study of this relation in the Camp 10 area is highly desirable. In anticipation of such study, a few additional comments are presented here.

A dominant type of soil exists in the zone of demarcation below Camp 10. This is a brown to black soil of fine-grained sub-microscopic texture. It contains clay with a very few bits of quartz and other resistant mineral grains

[7] The development of lichenological techniques for relative dating of moraines has been successfully employed in Scandinavia and the Alps in recent months. The work has been carried out by Erik Bergstrom in Swedish Lapland and by Etter Beschel in Austria. (See Zeitschrift für Gletscherkunde, 1950, also the description by Faegri, 1951.)

but for the most part it is a fairly mature soil which has lost all but the most insoluble of its original constituents. The darker variety consists of sub-microscopic fines and contains humus. The light (brown) variety contains a larger quantity of the loose crystals of unaltered minerals and hence may be considered as a more or less immature soil. Its brown color comes from limonite which has stained the clay to a yellow or reddish color. If there is much organic matter in the soil it tends to reduce the ferric iron (red) compounds into the ferrous state which has no conspicuous color. Thus, the more humic soil type does not tend to be red.

The contained humus is a colloidal mixture of humic acid and bacterial, fungal and algal decomposition products. Its fine texture is responsible for retaining moisture readily and thus consistent dampness is a characteristic of the darker soil. This dampness is accentuated by accumulations of the soil in undrained niches, on concave ledges and in gulleys. The dark soil is found in a mantle 6 to 24 in. thick which usually supports vegetation. Where there is vegetation, the process of soil development may be biogenic, in that the alteration, especially breakdown of feldspar into kaolin, is enhanced by the presence of carbon dioxide from humus. This soil when initially formed undoubtedly came from weathered rock flour and some of the alteration products previously described, such as the hydrous aluminum silicate (kaolin) and limonite which have been washed into local depressions. In some cases, along with the clay or kaolin, there has probably been potassium carbonate (K_2CO_3) as a complimentary decomposition product from orthoclase. This mineral constituent occurs in the abundant porphyroblastic schists and related granitic units in this area (See J.I.R.P. Report No.6, p. 116). The potash may become dissolved by water and removed, but some of it may also be held in the colloidal clay and thus made available as plant food at a time when the clay becomes transformed into soil.

Another soil-like mantle has formed on the Camp 10 area from disintegration of granitoid rocks. This consists primarily of quartz and plagioclase fragments from the granodiorite. The result is a light-colored, coarse-grained and highly permeable residuum often seen in sprinkled layers on top of the organic soil. In this, it is a retardent to plant growth. Taken alone, it does not support vegetation probably because of its coarse-grained nature and lack of associated potash.

On the slopes northeast of the research station, nearly to the summit of "Taku B", there is a heavy colluvial mantle of granulated and unproductive soil. Some of it consists primarily of dark fragments of hornblende admixed with quartz and plagioclase grains from disintegrated amphibolite. Many of the fragments are quite large and give the appearance of water-rounding leading one to suspect that there might have been a kame terrace here at a high still-stand of the Wisconsin "ice cap". They, however, are most likely all disintegration products as "cannon ball" weathering.
On some portions of the upper slopes, there is a fairly advanced development of vegetation upon which a long-range study was begun by the expedition ecologist.

In this general study, there is room for close integration and coordination between investigations of geological, ecological and glaciological nature and also of the local micro-meteorology. In summary consideration of nunatak soil, the following factors are especially involved when attempting glaciological inferences from the presence or lack of vegetation. (1) The kind of soil, its nature and mineral composition (best for plant growth if it has phosphate and magnesium); (2) amount of soil (thickest is best); (3) grain size (fine-grained best); (4) exposure and protection (whether towards the sun or sheltered); (5) angle of repose (whether subjected to repeated disturbance by sliding, etc.); (6) color (dark soil has lower albedo and higher humus content); (7) drainage pattern (water courses best for many plants); (8) presence of fungi (as aids to plant metabolism); and (9) porosity and permeability (important considerations in regard to the soil's water-holding capacity). By this it should be clear, that there can be other reasons, besides the proximity of a glacial limit, why a soil does not support vegetation.

From these notes, it is seen that several types of detritus are involved in a thin cover on portions of the central nunataks. The types of debris may be summarized as (a) fluvial-glacial clays, silts, and sands originating from rock flour and surface weathering products and forming humus-bearing soil; (b) sand and gravel colluvial residuum resulting mostly from scaling and granular disintegration of coarsely crystalline bedrock; (c) frost-riven angular blocks more or less in situ forming felsenmeer topography and (d) glacial morainic material and till usually with coarse angular fragments. All of these may be mixed and re-worked by gravity, by temporary stream action in gulleys and ravines and by sheet-wash on open slopes. They may also admix with detritus brought down by rock slides and avalanches and with aeolian material which is deposited from long distances or is transferred from nearby or adjacent slopes. These are all factors which must be considered in analysis of the morphology of nunatak surfaces and of the significance of their existing characteristics to former fluctuations in climate and related glacial conditions.

The broad sequence of several post-Mankato stages operative on the lower slopes of the central nunataks is outlined together with a few comments on their probable relationship to the foregoing discussion.

(1) Period of primary "ice cap" coverage during Pleistocene Epoch, with evidence for the earlier major stages not readily discernable on the highland nunataks since the record has been largely eradicated by glacial action of the Cordilleran end stage. This is assumed to have corresponded with the Wisconsin end stage of continental glaciation. The final pulsation of the Wisconsin age in this area probably corresponded to the Mankato sub-stage of continental glaciation. During culmination of the Wisconsin, there was a strong development of local topographic irregularities on the central nunataks and establishment of the deeper set of grooves now visible on the higher slopes. These are associated with the strongly pitted and kaolinized high level surfaces. The Mankato sub-stage

accentuated and modified earlier Wisconsin glacial features with further development of grooves and deep striae on the flattest surfaces at the more intermediate elevations. These are also somewhat weathered and with the older surfaces exhibit a mature development of lichen. It is difficult to differentiate features directly which may be attributed to earlier individual Wisconsin sub-stages.

(2) Post-Mankato deglaciation, probably characterized by considerable oscillation and minor resurgences. Culminated in removal of all ice from the area except in the highland. By virtue of this retrogression an alpine stage of glaciation was, in effect, produced with sub-stages involving minor fluctuations of disconnected local glaciers and resulting in a certain amount of cirque sculpture and of periglacial weathering features and grooving controlled by the previously formed local topographic irregularities. Development of crossed striae on glacier-covered bedrock, with the youngest striae prominently incised but with orientation locally controlled. Granular disintegration of ice-free outcrops which were amenable to hydration and mechanical breakdown. These outcrop surfaces today are characterized by frost-heaved felsenmeer and, in places, by a thick mantle of colluvial disintegration fragments.

(3) Interstadial warm stage (climatic optimum), with considerably less glacial coverage than today. Valley glaciers excessively receded and the regional snow line one to two thousand ft. higher than at present. Trunk glaciers at the base of central nunataks were several hundreds of ft. thinner than today and their termini some miles further up-valley. Development of soil through combined processes of mechanical and chemical weathering and washing-down of rock flour and other fines into local depressions. Initiation of heath mat and development of mature vegetation cover including even some willows on what are the present-day lower slopes of central nunataks. Extensive development of oxidized surfaces on many bedrock outcrops.

(4) Minor re-advance of ice in the 17th and 18th centuries, resulting in forest trim line at low levels and scour line at base of nunataks 30 to 100 ft. above present névé in the highland and up to 500 ft. above the glacier's present surface at low elevations. Perennial snow slopes and glacierets produced in areas which were ice-free during climatic optimum with the consequent operation of nivation processes and minor glacial scour resulting in very shallow and ill-defined local striae which may occur at an angle to directions of flow of former expanded stages. Differential removal of some of the older surface weathering products.

(5) Modern recessional trend, with pulsating retreatal characteristics, and the consequent exposure of scour zone above present ice surfaces. Development of youngest iron oxide stain, and first stage of granular disintegration on recently scoured outcrops which are most amenable to mechanical weathering. Also characterized by sporadic exposure of indurated, scratched and polished rock flour associated with most recent glacial expansion.

C. Geomorphological Observations at Low Elevations

During the latter part of the summer, several members of the project had an opportunity to make some reconnaissance observations on the geomorphology of the Taku Valley, the Taku Inlet, Gastineau Channel and its tributary valleys northwest of Juneau. The following studies were attempted which for the most part should be considered as portions of a more comprehensive investigation of the glacial geology of the ice field's marginal area which it is necessary to extend into several subsequent field seasons. For this reason, the 1950 efforts are mentioned here only in the following brief outline.

(1) Ground and aerial reconnaissance of the Taku River Valley as far east as Red Creek about 10 miles above the confluence of the Talsekwe and Taku Rivers and 17 miles northeast of the International Border at Flannigan Slough.[8] The ground journey was accomplished by hand-lining a small boat up the river. During the reconnaissance, special attention was given to the evidence of former glaciation in the upper valley. The nature of river terraces and of recent sedimentation in the valley was observed for purposes of assessing the possibilities of future field work. Together with other geomorphic features, the terraces were associated with the eastward channeling of a major glacial lobe from the Juneau Ice Field during one or more inundated "ice cap" stages of Pleistocene time.

(2) Reconnaissance of the Talsekwe River Valley and aerial photographic record of Talsekwe Glacier's frontal position and related morphological features. Information was obtained concerning the 1950 break-out of the "Tulsequah" ice-dammed lake which was found to have experienced a double flood in this year. The first break-out occurred sometime in the first week of July. This was a minor discharge which raised the Taku River's level two and one-half ft. at the Tulsequah Canadian Custom's Station. The second flood reached its peak on July 29th when it raised the river level seven ft. During the main phase of the flood, the mining operations bridge across the Talsekwe River Valley was destroyed. The high water mark from this year's break-out at Lower Boundary Creek was recorded at ten and one-half ft. above the river's mid-September normal low-water level. In years of excessively high flood, the waters rise as much as 15 ft. above normal at the Taku-Talsekwe River confluence. The 1950 break-out is considered of average dimension.

(3) Photogrammetric ground record of 1950 positions of Taku, Norris, Hole-in-the-Wall and Twin Glaciers from previously established reference stations.

(4) Reconnaissance study of moraines and sedimentation in vicinity of the Taku Glacier and Twin Glacier Lake, including test samples taken of bottom sediments in the lake by means of a Phleger Sampler (loaned by the Woods Hole Oceanographic Institute). The purpose of these tests was to evaluate field conditions for the development of larger equipment for use in a subsequent detailed study.

[8] See Map 931A in "The Taku River Map Area, B.C." Geological Survey Memoir No. 2484, Canada Department of Mines and Resources.

(5) Investigation of the morphology and stratigraphy of the glacial-deltaic terrace at Taku Lodge, its relationship to former marine conditions, and the mid-18th century advance of the Taku and Hole-in-the-Wall Glaciers which partially dammed the river at its entrance into Taku Inlet.

(6) Observations on the sequence of glacial till, gravel and intercalated forest remains in the outwash plains of two glaciers on the southwest side of the ice field. Dating the forest levels was initiated by radiocarbon analysis of buried interfluctuational forest remains. The age of the uppermost layer of forest litter, found approximately eight ft. below the surface of the pitted outwash plain and 100 yds. in front of the south central terminal ice cliff of Mendenhall Glacier, has been determined to be 1790 ± 285 years (Kulp, Feely, and Tryon, 1951, p. 568). This indicates that 1500 or 2100 years ago there was a mature forest at the terminus of the Mendenhall Glacier at a location which less than 10 years ago was covered with one hundred or more ft. of ice. The buried forest level has only been exhumed in the last several years by undercutting action of the outwash stream. The other collection of inter-stadial wood was found beneath the terminus of Herbert Glacier.

(7) The collection was made of a suite of Pleistocene marine shells for study and correlation from several raised beach and delta sites in this district. Identification of the shells is being made for listing in a subsequent report.

From the preliminary study of this collection, it would appear that a system of at least four former marine levels (stages?) exist on the west side of the ice field. For differentiation, these may be termed the 30-ft., 60-ft., 100-ft. and 500-ft. marine terraces. The elevation of recorded collection sites may not represent the true marine limit since little is known about the thickness of the associated strata and because the heavy forest cover makes it difficult to trace their extension. The field problem is further complicated by the fact that the broken nature of shells at some sites indicates that the related Pleistocene glaciers in some cases may have plowed into these beds and considerably disturbed their continuity. The 500-ft. marine level has also been reported on the eastern side of the ice field (see Miller, M.M., 1952, p. 83).

The existence of raised beach levels from post-glacial emergence can be observed for great distances along this coast. They are especially prominent towards the west in the Yakutat-Yakataga area where, on the coastal foreland, a sequence of strand lines can be seen. The magnitude of this epeirogenic uplift in Southeastern Alaska, however, has not been studied in detail. Available evidence indicates that the uplift has not been at a constant rate. The existence of several stages of marine benches and wave-cut platforms on the western side of some of the adjacent islands in the Alexander Archipelago as well as farther west on Middleton Island in the Gulf of Alaska supports this view (Miller, D. J., 1953). A stronger development of these features in bedrock in the Juneau area was probably precluded by the fiord-like nature of the coast and the fact that floating and stranded ice bergs and sea ice in the waning stages of the Pleistocene glaciation further tended to reduce the effectiveness of wave action.

The upwarp described above has undoubtedly been occasioned by the release of load on the earth's crust in consequence of regional deglaciation. An investigation of recent tide-gage records along this coast should yield some significant information on present eustatic changes which may be independent of the local crustal warp. In future studies, a search should also be made for field evidence of submergence of this portion of the coast in the early Pleistocene. A study of the known bathymetry of various channels and fiords might yield information on the former changes in sea level. Some of this information is recorded in existing coastal charts. Taku Inlet and the waters of the Juneau area were first indicated on the 1892 edition of Chart 8300, U. S. Coast and Geodetic Survey. Subsequent hydrographic data have been published on revised editions of this and related charts.[9] (The name Taku Glacier first appeared on the 1906 edition. On the earlier editions, it was termed "Foster Glacier".)

In addition to bathymetric data in the fiords, available information on the off-shore continental shelf profile and its relationship to uplifted coastal plains elsewhere in Southeastern Alaska should be reviewed. Evidence of terrestrial organic matter in bogs which were once depressed below sea level and of coarse stream gravels in one form or another deposited below sea level should be looked for. The several exposures of deltaic material now well above tide water in Gastineau Channel, north of Juneau, are criteria of this kind. The Taku Valley contains a wealth of information on details of the regional submergence and subsequent emergence. A seismic profile across the valley in the vicinity of Twin Glacier Lake and also longitudinally towards the present tidal inlet would be of much interest. This valley contains a very thick section of fluviatile material as indicated by the 400- to 600-ft. depth of Twin Glacier Lake. If a bedrock threshold exists west of this lake or oceanward somewhere in the present fiord, the valley was considerably over-deepened by Pleistocene glacial action. If not, it was for the most part formed by continual erosion of the antecedent Taku River. In such a direction lies the answer to whether Twin Glacier Lake is part of an old "filled fiord" or whether it is in a submerged river-cut trench which, in spite of the present day upwarp, has not fully rebounded to the position it held in respect to normal sea level in pre-glacial Pleistocene time.

[9]For reference purposes, the list of available U. S. Coast and Geodetic Survey charts pertaining to this area is given here: (1) Chart 8300, Lynn Canal and Stephens Passage, published in 1892 from surveys of 1888-1890; shows bathymetry of above named channels as well as Taku Inlet; (2) Chart 8300, 1895 revised edition; (3) Chart 8300, 1906 edition, from surveys of 1902-1906; includes bathymetry of Taku Inlet; (4) Chart 8300, 1919 edition, revised from surveys of 1907; (5) Chart 8300, 1926 edition, revised from surveys of 1923; (5) Chart 8300, 1926 edition, republished 1930, revised from surveys of 1923; (7) Chart 8202, Midway Island to Cape Spencer, including Lynn Canal, published 1936, shows bathymetry of Stephens Passage, Lynn Canal and Taku Inlet, and Icy Strait; (8) Chart 8235, Gastineau Channel and Taku Inlet, published 1941, from surveys of 1936-37; (9) Chart 8235, revision under preparation for publication in 1953-54 from field surveys of 1952.

D. Bedrock Geology on the Ice Field

Two members of the project conducted investigations in 1950 on the bedrock geology of several nunataks near the central and west central sector of the ice field. These studies have formed the bases for Master's Theses in the Department of Geology at the University of Washington and the Department of Geology at Columbia University. Professor Peter Misch, from the University of Washington, served as advisor to these men during his visit to the ice field in August. The program of R. B. Forbes continued his 1949 field work on the petrology and petrogenesis of a suite of rocks from the west central nunataks. This work has been partially reported on in Chapter VI of J.I.R.P. Report No. 6. Studies by Arthur Gilkey dealt with structural aspects of the nunatak "Taku B" (Fig. 3) with special reference to the problem of granitization (Gilkey, 1951).

XI. PLANT ECOLOGY

The botanical program in the 1950 season involved investigations both on the ice field and at periglacial sites near sea level. The low-level studies were largely a continuation of the research program begun in the previous year. In the névé area, several new lines of research were attempted which, although partly experimental in this field season, have proved the effectiveness of certain techniques for subsequent work. A resumé of the phases of this work is given below. Comments on the ice field program are taken from informal notes provided by C. J. Heusser. The report on the Herbert Glacier glacio-ecological investigation is from information provided by Professor D. B. Lawrence.

A. Analysis of Englacial Pollen

It was planned in this season to ascertain whether pollen analytical techniques were of practical use in differentiating seasonal strata of firn and ice not characterized by annual dirty layers or other megascopic features of an ablation level. The technique employed was similar to that which was first introduced by Dr. Volkmar Vareschi in his pollen-analytical studies of certain glacier structures and firn profiles in the Alps (Vareschi, 1937, 1942).

Samples of pollen were obtained from cubic-ft. sections of firn taken from the walls of crevasses and pits at sites 10B and 10C on the Taku Glacier (Fig. 3). The firn was melted in pails and the resulting water left to stand for 16 to 24 hours so that any contained organic matter would settle to the bottom. During this period, the pails were covered with a light tarpaulin to prevent atmospheric contamination. Most of the water was then decanted and the remaining liquid poured into 1000 cc. beakers where it was allowed to settle again for 16 or more hours. The decanting process was repeated and the residual sediment collected in 8-dram vials in which was also placed a preservative. These vials were then stored for later transportation from the ice field and subsequent microscopic analysis. In the laboratory, the total number and species of pollen grains in each sample were determined.

The results of this summer's work are not as yet complete and will be presented elsewhere. However, valuable experience was obtained which was put to good use on the ice field in the summer of 1952. The results of the 1952 program are discussed in a recent article (Heusser, 1954b).

B. The Collection of Atmospheric Pollen

Glass slides, coated with glycerine jelly, were exposed to the atmosphere for a week at a time at the Camp 10 research station and on the roof of the U. S. Forest Service warehouse in Juneau. In this way, it was hoped to obtain a comparative record of the quantity of pollen which is deposited on the ground at these two sites. The period of record was only from July to September and therefore does not represent the full flowering season. Ideally, such a study should be conducted throughout all of the spring, summer and autumn weeks in which pollen is produced. Unfortunately, the slides at the ice field site were misplaced at the end of the field season. (Further records have been obtained at Camp 10 and at Juneau in subsequent summer seasons.)

By a special technique, atmospheric sampling was also accomplished during rainy weather. It was found, however, that very little pollen is in the air over the ice field during periods of inclement weather. Heusser reports that only the pollen of pine, an excessively buoyant species, was detected.

C. Botanical Quadrats and Plant Collections

On the slopes of "Taku B", adjacent to the research station site, seven 10-ft. x 10-ft. quadrats were established and marked by rock cairns. Each was located at a different elevation and exposure, and at a different distance from the glacier. The distribution and species of plants in each quadrat were recorded. In the years to come, it is hoped that these quadrats may be revisited and thereby further knowledge gained on the type and rate of plant succession on this deglaciated terrain. Of particular interest will be the length of time that it takes at each location for the development of a climax assemblage.

Plant collections were made on the central ice field nunataks including "Taku A", "Taku B", "Exploration Peak" and "Juncture Peak". A total of 16 species of lichen and 20 of moss was collected. In addition, 27 previously unreported species of vascular plants were brought from the ice field to supplement the collections obtained in 1948 and 1949.[10] One hundred and four plant specimens were collected from muskeg areas on the western border of the ice field. The 1950 collections have been deposited in the following herbaria: lichens, University of Wisconsin; mosses, Rutgers University; vascular plants, Oregon State College. The lists of the individual species are to be included in a later report.

[10] See J.I.R.P. Report No. 1, Appendix C and J.I.R.P. Report No. 6, Appendix F.

D. Muskeg Investigations

It is known that glacier advance and subsequent recession are followed by plant successions on the deglaciated terrain. The changes in resulting forest composition in the post-glacial period is often well-recorded in buried layers of tree pollen in columnar sections of peat. For this reason, between Lemon Creek and Lena Beach, seven muskeg areas were sampled for peat using a Hiller-type peat bog sampler. Samples of wood were also taken from the organic sedge basement of several muskegs. One of these, at Lemon Creek, was submitted to the Age Determination Laboratory of Columbia University's Lamont Geological Observatory. The Carbon-14 analysis of this wood provided a sample age of 3,300 $\pm$ 250 years (Kulp, Tryon, Eckelman, and Shell, 1952).

Information resulting from these studies is contained in articles by Heusser (1952, 1953, 1954a).

E. Dendro-Chronological Study of Moraines

Botanical evidence available on periglacial terrain at low elevations has been used by Professor D.B. Lawrence for detailing the recent history of glacier fluctuation at the periphery of this ice field. In the summer of 1950, Dr. Lawrence succeeded in refining some of his previous glaciobotanical studies on several glaciers in the southern sector of the ice field. Particular emphasis in this season was placed on the recent recessional moraines of the Herbert Glacier, situated at Lat.58°32'N., Long.134°43'W. (Fig. 2).

For this study, dendro-chronological techniques were employed (Lawrence, 1950a). The work depended upon obtaining samples of wood from trees growing on well-delineated moraines near the present-day ice terminus. Sections of wood were taken a few feet up from the base of the tree trunks and from the bark inward to the center. The tools used for these studies included saws and Swedish increment borers[11] plus a sanding machine and microscope for the counting and study of tree rings in the laboratory. Aerial photographs greatly helped in the location of sample sites and in the plotting of data obtained.

Details of the technique and general results of the 1949 season of work on this and five other glaciers emanating from the Juneau Ice Field have already been reported in another publication (Lawrence, 1950b). A summary of the field method and a detailed discussion of the results of the 1950 investigations have also been published by Dr. Lawrence (1951) in a more recent paper. Therefore, only a resumé of the 1950 field work is included here. The fundamental assumptions upon which this research is based and the limitations of the field method are described in the referenced papers. Some of the broader conclusions and theoretical implications, in terms of the periodicity of post-Wisconsin climate fluctuations and the effects of this periodicity on the regime of the Juneau Ice Field, are also in these references.

[11]Manufactured in standard 40 cm.(15.75 in.) lengths by Beus and Mattson Co., Mora, Sweden and may be procured through Keuffel & Esser Co.,in New York City (Price about $30.90). For larger trees, Dr. Lawrence has used a special 61 cm. (24 in.) length which is also available from this firm.

The Herbert Glacier is an outflowing tongue of the Juneau Ice Field about 10 miles long and one mile wide near its terminus. It rises on the 4000- to 5000-ft. névé west of Camp 9A (Fig. 2), and forms one of the westernmost lobes of the ice field. The terminus is at an elevation of about 100 ft. and can easily be reached by a good trail from the Glacier Highway. It lies a distance of about 18 miles northwest of Juneau.

The terminal lobe of this glacier during its mid-eighteenth century extension was of a bulbous semi-piedmont nature. Dr. Lawrence reports a notable "closeness of spacing and regularity of arrangement of the terminal and recessional moraine formed in the first 160 years of general recession. .....The horizontal recession rate has not been uniform since recession began about 1740. The first 0.4 mile required 114 years (1746-1860) according to estimates based on ages of oldest trees on the terminal moraine and the youngest moraine; this amounts to an average annual recession rate of about 18.5 ft. In the next half century following 1860 until the 1909-1910 position of the ice front was reached, the recession amounted to 0.6 mile, with an average annual recession rate of about 53.4 ft. In the latest 38-year period (1910-1948), the recession has amounted to about one mile with an average annual recession rate of about 139 ft."

The field evidence indicates that the recessional moraines, formed as a result of the above noted retreat, were best developed in the 1740 to 1860 period when the rate of deglaciation was slowest. In the period of most rapid frontal degeneration since 1910, no prominent moraines were formed.

The trees growing on each moraine were studied and the ages of the morainic ridges thereby determined by tree-ring counts. Dr. Lawrence states that "these data do not conflict with the hypothesis proposed in my earlier paper, that there should be a tendency for a ridge of till (moraine) to be deposited along the line of the receding terminus of this glacier at about the time of sunspot minimum of each 11-year cycle". In view of the 1950 field work, he writes that the primary modification which he now suggests in this thesis is that it would hold true only "when the general rate of recession is suitable". Thus, if the rate of recession is relatively rapid, as has been the case since 1910, the debris will tend to be distributed evenly as a ground moraine without development of ridges.

Two of the moraines show composite crests which although closely spaced indicate distinctly separate glacier resurgences. Since the tree-ring analyses on each crest show roughly the same age, this is assumed to represent minor re-advances of the glacier over a period of two or three years. In summary, Dr. Lawrence reports "This is as far as the research has led us at present. The detailed results are stimulating but not yet at a stage of development sufficiently advanced to allow broad applications. I would voice the opinion that the Herbert Glacier and others that lead from the Juneau Ice Field have great potential for further information because the vegetation is relatively undisturbed and the Sitka spruces (Picea sitchensis (Bong.) Carr. have apparently been faithful recorders of time for more than 200 years following shortly after moraine formation" (Lawrence, 1951, p. 164).

XII. THE MAPPING PROGRAM

This field season resulted in the establishment of further horizontal and vertical surveying control especially in the central and western sectors of the ice field. The survey program, as in 1949, was carried forward by R. G. Merritt; with C. R. Wilson assisting. For most of the ice field work, a Wild T2 Theodolite was employed with supplementary surveys at low elevations being made with a Transit Theodolite. All travel to the survey stations was accomplished by foot or on ski. In order to occupy the summits of reference nunataks, roped mountaineering techniques were essential on occasions. The surveyors used the following camps in order to carry out the program: Camps 4, 10, 11, 13, 14, and 16 plus trail camps established where necessary.

Because of poor visibility conditions in early summer, most of the surveying was accomplished in August and early September. Most of the 13 transit stations established in 1949 were re-occupied for refined triangulation with the theodolite. Thereafter, 31 additional key control stations were located either by direct occupation or by fixing the position from other stations.

All occupied survey sites were of fourth-order accuracy; however, they were based on two third-order triangulation points established by the U. S. Coast and Geodetic Survey in 1923 and used by the project in 1949. These were STATION TWIN and STATION NORRIS, at opposite ends of a 68,820-ft. base line. (Fig. 2). A description of the refinements to the 1949 network is presented in J.I.R.P. Report No. 6. The computations for both years are on file at the American Geographical Society.

A list of the additional 1950 stations, including their elevations and descriptive locations, is given in Appendix T for reference by future field parties. These data, with supplementary material from 1951 and 1952, are being used for refinement of the U. S. Geological Survey reconnaissance series map of the western half of the ice field.[12] All elevations given in the appendix, where previously occupied stations are concerned, are corrected values from the 1950 survey.

[12] See Juneau B-1 and B-2 sheets, U. S. Geological Survey, Alaska Reconnaissance Topographic Series, 1:250,000, published in 1949 and 1951.

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XIV. APPENDICES

APPENDIX A

PERSONNEL

I. MEMBERS OF MAIN FIELD PARTY (one or more months)

Glaciology and Geomorphology

M. M. Miller	Department of Exploration and Field Research, American Geographical Society and Department of Geology, Columbia University; glaciology, geomorphology, organization, project director.
R. L. Nichols	Professor of Geology, Tufts College; geomorphology, senior scientific adviser.
F. A. Small	Goddard College (undergraduate); glaciology assistant, field secretary, food committee.
P. V. Livingston	Department of Geology, University of Oregon; glaciology, ecology assistant, food committee.

Geology

R. B. Forbes	Department of Geology, University of Washington; geology, aerial logistics.
A. K. Gilkey	Department of Geology, Columbia University, geology, equipment committee.

Mineralogy

H. Bader	Engineering Experiment Station, University of Minnesota and Snow, Ice and Permafrost Research Establishment, Army Corps of Engineers; mineralogy, ice petrofabrics, senior scientific adviser.
G. Wasserburg	Department of Geology, University of Chicago (undergraduate); ice mineralogy, assistant to Dr. Bader.

Core Drill Program

A. K. Anderson	E. J. Longyear Company; rotary coring expert and drill supervisor.
M. C. Marcus	University of Washington (undergraduate); geology, drill assistant.

APPENDIX A (continued)

Meteorology

F. A. Milan	University of Alaska (undergraduate); meteorology, mechanics, radio communications.
N. E. Turner	Mt. Washington Observatory; meteorology, mechanics, radio communications.
C. O. Harrington	Blue Hill Meteorological Observatory, Harvard University; meteorology.
C. E. Anderson, Sgt. U. S. A. F.	Arctic Weather Central, Air Weather Service; meteorology, U. S. Air Force representative.

Ecology

D. B. Lawrence	Professor of Botany, University of Minnesota; plant ecology, in charge of low-level ecology team.
E. G. Lawrence	University of Minnesota; ecology assistant.
C. J. Heusser	Department of Botany, Oregon State College, upland ecology, pollen-analysis.

Mapping and Survey

R. G. Merritt	Department of Civil Engineering, California Institute of Technology; in charge of survey work, mapping.
C. R. Wilson	Case Institute of Technology (undergraduate); mapping assistant, glacier movement surveys, equipment committee.

Medical

W. Nicholl, M. D.	Assistant Director of Health, University of Montana; medical officer, food committee.

II. SHORT-TERM MEMBERS OF FIELD PARTY (up to three weeks)

A. W. Thomas	U. S. Forest Service; liaison, logistics, Forest Service representative.
V. R. Fritz	Photography, supply.
H. J. Kothe	The Fleischmann Laboratories, New York City; chemist, glaciology assistant.

W. R. Latady	Aero Service Corporation; photography, survey.
E. Brown	Juneau, field assistant.
T. Stewart	Juneau, field assistant.

III. VISITORS FOR SHORT PERIODS OF TIME

(a) Scientific Advisers and Special Representatives

L. O. Quam	Geography Branch, Office of Naval Research; geomorphology.
W. O. Field	Department of Exploration and Field Research, American Geographical Society; glaciology.
P. Misch	Professor of Geology, University of Washington; geology.

(b) Non-scientific Visitors and Liaison

B. Balchen	Colonel, U. S. Air Force, Arctic Adviser, Alaskan Air Command (formerly, Commanding Officer, 10th Air Rescue Squadron); observer.
W. A. Orr	Lt. Colonel, U. S. Army, Arctic and Sub-arctic Investigations Staff, Corps of Engineers, observer.
J. Roberts	Wakefield, Mass.; photographer.
L. Thomas	Pawling, New York; public relations.
D. Williams	Juneau; communications, liaison.
K. Loken	Juneau; local pilot, liaison.

IV. MILITARY PERSONNEL, IN PRIMARY AERIAL LOGISTIC SUPPORT OPERATIONS

(a) Alaskan Sea Frontier, Naval Air Station, Kodiak

R. F. Curry, Lt. (J.G.), U. S. N., pilot.

R. C. Randall, ADC. AB, U. S. N., co-pilot.

W. B. Thomas, AD3

J. Hill, AD3

F. H. McLerran, AL3

APPENDIX A (continued)

(b) <u>Alaskan Air Command, 10th Air Rescue Squadron, Elmendorf AFB</u>

R. A. Ackerly, Major, Acting Commanding Officer, 10th Rescue Squadron.

V. W. Rudd, Lt., pilot.

R. L. Holdiman, Capt., pilot, executive officer.

Sparrvohen, F., Capt., pilot.

J. Kangus, Capt., pilot.

L. Cronin, Lt., pilot.

J. Royale, Lt., pilot.

J. C. Blazier, M/Sgt

G. W. Caton, S/Sgt.

R. A. Tumlinson, Sgt., crewman.

F. R. Hamel, Sgt., crewman.

R. Beasley, Sgt., crewman.

D. Cottrell, Sgt., crewman.

Two other pilots checked out on ski-landings, names not recorded.

APPENDIX B

GUIDE SHEET TO SEMI-PERMANENT CAMPS WITH CACHES ON THE JUNEAU ICE FIELD

Camp Desig.	Approx. Elev. (in ft.)	Approximate Coordinates Lat. and Long. (see Fig. 2)	Year Estab.	Descriptive Location and Remarks
1	60	58°34'00"N. 133°55'00"W.	1948	Approx. 200 yds. E. of vertically-trending trap rock dike on bedrock cliff, exposed at water's edge near E. side of West Twin Glacier. Camp site 10 ft. above normal lake surface. At average water level boat mooring possible on small flat ledge of rock, with deep water on lake side. When lake is fairly clear of ice, pontoon aircraft may easily land and disembark or embark passengers at this site which is also only 40 minutes by outboard motor boat travel from Taku Lodge.
2	2100	58°35'00"N 133°56'00"W.	1948	In the shelter of a clump of 20-foot hemlocks just below timber-line on West Twin Glacier fault-line route, 100 ft. northwest of couloir. Route camp.
3	4300	58°36'30"N. 133°55'30"W.	1948	On 15° head slope, S. side of "H" Basin. Main base camp of 1948 expedition; cache of supplies buried by subsequent drift snow; not ablated out in 1949-52.
4	4000+	58°37'30"N. 133°57'00"W.	1948	S.E. side of ice field. On bedrock crest of lower end northward trending ridge of Research Peak; 100 ft. above névé surface. Large cache of equipment established here in 1949. Route camp and meteorological station and cache with pyramidal tent. 1948 camp on névé at base of ridge at 3800-3900 ft. elevation.
5	4500	58°41'00"N. 134°03'00"W.	1948	In rock col W. end of "Scatter" Peaks. S.W. side and overlooking "Y" Basin. Route camp and supply cache.

APPENDIX B

(continued)

6	4600	58°42'40"N. 133°51'00"W.	1949	E. side of ice field. On S. flank of Michael's Sword, 1/2 mile W. of Devil's Paw; exploration and survey cache with pyramidal tent.
7	4000(?)	59°00'00"N. 134°05'00"W.	1952	N. E. sector of ice field, on Llewellyn Glacier surface just above névé line zone.
8	6200+	58°47'30"N. 134°08'30"W.	1950	N. E. sector of ice field, on relatively level felsenmeer rock surface at lower end of exposed rock ridge trending W. from Mt. "Moore". Full cache of equipment and supplies with hexagonal tent and meteorological instruments. Met. and glaciological research station. Subsidiary camps 8x and 8y on névé surface 1 mile to N. W. in 1951 and 2 miles to the W. in 1952, respective elevations 5960 and 5850 ft. These sites lie close to the Llewellyn-Taku Glacier divide, about 18 glacier miles from Camp 10.
9	4700	58°42'30"N. 134°21'20"W.	1949	N. W. sector of ice field. Lower end of S. ridge of South Echo Peak (Taku E) N. W. edge 4500-foot Taku Glacier névé, met. station and survey and route camp.
10	3862	58°39'00"N 134°11'30"W.	1949	Base camp and research station near center of main portion of ice field; a nunatak ridge and summit, 300 ft. above Taku Glacier surface on W. slope of "Taku B". Met. station, communications base and central glacier research station 1949-52; ecological quadrats.

APPENDIX B

(continued)

10A	3590	58°38'30"N. 134°12'00"W.	1949	Initial firn research camp and light skiplane landing site for Camp 10. At base of western rock slope, 1/4 mile S. W. of Camp 10. Eastern end of seismic and movement stake Profile No. IV.
10B	3570 ±	58°37'30"N. 134°14'00"W.	1950	Near center of Taku Glacier. Englacial research camp and heavy skiplane landing site; location of aluminum deformation pipe and thermistor cables; Camp site marked with 20-foot tripods and 40-foot aluminum tower (subsequently broken in 1951-52.)
11*	2900	58°34'00"N. 134°06'00"W.	1949	N. end of "Goat" Ridge on heather-covered rock surface with ample water supply from nearby snow slopes and small drainage streams. Cache with pyramidal tent and other equipment. Route camp and seismic, met., and survey station.
12	2450 ±	58°30'00"N. 134°01'30"W.	1949	Hole-in-the-Wall Glacier ridge summit at S. end of "Goat" Ridge. Camp lies 1/4 mile S. of deep cleft in ridge top. Route camp and met. station with pyramidal tent and instruments in cache.
14	4700 (?)	58°32'00"N. 134°18'30"W.	1949	Located on small, flattish nunatak on N. side of W. branch Taku Glacier near S. E. flank of Taku Range. On route, half-way between Camps 10 and 16. Geological, survey and route camp. Cache of miscellaneous supplies and pyramidal tent.

*In JIRP Reports Nos. 2 and 6, this is termed Camp 11A. Its designation has since been changed to Camp 11. The former Camp 11 was the seismic route camp on the glacier surface at the confluence of the Northeast and the main branch of the Taku Glacier. Its designation has been changed to Camp 13 (no cache).

15	5450	58°41'30"N. 134°33'30"W.	1950	On lower end of rock ridge, extreme N. W. edge of Taku-Eagle Glacier névé. Lies above "Arch Band" Glacier flowing into "Berners Bay Trench". Met. station and survey and glaciological camp; also site of ecological quadrat. Miscellaneous equipment including meteorological instruments and hexagonal tent.
16	4300	58°24'30"N. 134°20'30"W.	1950 (rec. 1949)	On summit of rock ridge outcrop between main Lemon Glacier and the northern extension of its névé. On this névé in 1951 a Piper Cub equipped with wheel-skis successfully landed supplies and equipment. Meteorological station, survey and route camp. Proposed glaciological research station subsidiary. Cache with hexagonal tent and instruments.
Taku Lodge	20	58°30'00"N 133°56'00"W.	--	Five miles above mouth of Taku River; served as low-level base station and temporary met. station in 1948-52.

Note: In this appendix, 18 main camp sites, not including Camp 13, are listed. The following special or emergency camps have also been used in the 1949 and 1950 seasons; however, no significant caches remain at the present time: Camps 1A, 1B, 2B, 6A, 7A, 8X, 8Y, and 9A. Camp 7A is the designation given to a prospector's cabin in the Llewellyn Inlet of Lake Atlin. Knowledge of this site may prove useful to future field parties. It is at 2500 ft. elevation and 2 miles from the terminus of Llewellyn Glacier. The locations of most of these subsidiary camps are shown in Figure 2 and described on Page 2 of JIRP Report No. 5.

APPENDIX C

ABLATION RECORDS (data which is not included in Fig. 5)

Ablation in inches of firn, sp. gr. 0.5

I. Site $10B_1$ (3580 ft.) on névé surface, 1/4 mile east of Camp 10B; 2/3 of the way between 10A and 10B.

Dates, 1950 (inclusive)		Ablation (total), in.	Ablation (per day), in.
July	18 - 24	8.5	1.21
	25 - 26	2.38	1.19
	27 - 31	7.5	1.50
Aug.	8	2.0	2.0
	9	2.5	2.5
	10 - 14 (1000 hr.)	13.2	2.6 +
	17	3.0	3.0
	21	2.5	2.5
	22 - 27 (0800 hr.)	10	1.4 +

II. Camp 10A, (3590 ft.)

Dates, 1950 (inclusive)		Ablation (total), in.	Ablation (per day), in.
July	5 - 13	7 +	0.8 +
	14 - 18	14	2.8
	26	3.5	3.5
Aug.	8	2.0	2.0
	9	3.0	3.0
	10 - 14 (1000 hr.)	14.8	3.0 +
	16 - 18 (0800 hr.)	5.5	2.8-
	21	3.0	3.0
	28 - Sept. 1	7.3	1.5 +

APPENDIX D

FIRN STRATIGRAPHY

I. Pit A. Camp 10B, Taku Glacier (see Fig. 11) July 18, 1950

Depth*(cms)	Horizontal Ice Structures and Layer Boundaries	Remarks
0 to 3.2	30 mm ice stratum	Prominent top ice strata
14.6	12 mm ice stratum	
17.8	6 mm ice stratum	
24.2	9 mm ice stratum	
36.9	9 mm ice stratum	
62.3	12 mm ice stratum	Double ice stratum
67.4	6 mm ice stratum	
68.3	3 mm ice stratum	
74.3	Lenses	Intermittent
78.8	Lamina	Thin
82.6	Lamina	Thin
90.2 to 95.3	6 to 50 mm ice stratum	Thickens
109.3	Lamina	Thin
110.5	Lamina	Thin
113.5	Lamina	Thin
119.4	12 mm ice stratum	Thickens
139.7	6 to 25 mm ice stratum	Thickens
147.4	6 to 18 mm ice stratum	Thickens
159.4	12 mm ice stratum	
167.3	12 mm ice stratum	
173.0	12 mm ice stratum	
174.6	6 mm ice stratum	
182.2	3 mm ice stratum	
190.2	6 mm ice stratum	
193.4	6 to 18 mm ice stratum	
205.8	25 mm ice stratum	
214.7	25 mm ice stratum	
224.8	12 mm ice stratum	Icy zone
251.5	37 mm ice stratum	Icy zone
259.1	25 to 37 mm ice stratum	Thickens
266.1	6 mm ice stratum	
332.7	50 mm ice stratum	
340.4	1 to 2 mm ice stratum	
353.9	6 mm, 12 mm, and 6 mm ice strata	Composite ice strata
359.0	50 mm ice stratum	
366.6	12 mm ice stratum	
372.9	12 mm ice stratum	
377.5	12 mm ice stratum	
391.2	ice stratum	

*All measurements from 30 mm ice stratum at surface on July 18, 1950 to top of ice structure involved.

APPENDIX D

(continued)

II. Pit C. (Crevasse III), Camp 10B, Taku Glacier (see Fig. 8) July 21, 1950

Depth*(cms) Below July 21 Surface	Horizontal Ice Structures and Layer Boundaries	Remarks
0 to	Firn	
50.8	6 mm ice stratum	
101.6	9 mm ice stratum	
105.5	6 mm ice stratum	
111.8	12 mm ice stratum	
119.4	Two 6 mm ice strata	Closely spaced
127.0	9 mm ice stratum	
137.2	6 mm ice stratum	
144.8	6 mm ice stratum	Lenses
160.1	18 mm ice stratum	
191.8	12 mm ice stratum	Lense-shaped sections prominent (probably represent sun-cupped undulations of 1948-49 ablation surface
202.0	12 to 25 mm ice stratum	
208.3	9 mm ice stratum	
254.0	6 mm ice stratum	
259.1	18 mm ice stratum	
276.9	6 to 18 mm ice stratum	
297.2	6 to 25 mm ice stratum	Lensing in sections
302.3	6 mm ice stratum	
304.8	6 to 9 mm ice stratum	
308.7	6 mm ice stratum	
316.3	3 mm ice stratum	
320.1	6 mm ice stratum	
331.5	9 mm ice stratum	Thickens to 37 mm to northward
337.9	12 to 25 mm ice stratum	Thickens to 75 mm to northward
350.6	9 mm ice stratum	
376.0	12 mm ice stratum	
386.1	18 to 25 mm ice stratum	
401.4	3 mm ice stratum	
406.4	6 to 9 mm ice stratum	
414.1	9 mm, 6 mm and 6 mm ice strata	In close sequence

*All measurements taken to top of the ice structure involved

APPENDIX D

Pit C. (Crevasse III) Camp 10B (continued)

Depth (cms) Below July 21 Surface	Horizontal Ice Structures and Layer Boundaries	Remarks
434.4	6 mm ice stratum	
436.9	9 mm ice stratum	
447.1	6 mm ice stratum	
448.4	12 mm ice stratum	
449.6	6 mm ice stratum	
452.2	9 mm ice stratum	
464.9	6 mm ice stratum	
480.1	6 mm ice stratum	
490.3	62 mm ice stratum	Irregular
487.7 to 518.2	Undulating 9 mm to 12 mm ice stratum	Unconformable seasonal boundary representing late summer ('47-'48) sun-cupped surface (Sept. '48)
523.3	12 to 50 mm ice stratum	

III. Pit C. (North side, Crevasse III), Camp 10B, Taku Glacier, August 27,1950

Depth* (cms) Below Aug. 27 Surface	Horizontal Ice Structures and Layer Boundaries	Remarks
30.5	25 mm ice stratum	Lensing in and out
33.1	Annual dirty layer	1948-49 late summer ablation surface.
38.1	6 mm ice stratum	
55.9	6 mm ice stratum	
61.0	6 mm ice stratum	
106.7	25 to 62 mm ice stratum	Lensing, thickening and thinning, somewhat undulated, with slightly irregular top; smooth and flattish base
116.9	6 mm ice stratum	Delineating a 75 mm thick icy zone
119.4	12 mm ice stratum	
122.0	9 mm ice stratum	
139.7 to 144.8	37 to 50 mm ice stratum	Lensing
152.4	1 to 2 mm ice lamina	Grades to eastward into 62 mm ice stratum, 2 feet away
154.9	1 to 2 mm ice lamina	
157.5	1 to 2 mm ice lamina	

*All readings taken to top of ice stratum involved

APPENDIX D

Pit C. (North side, Crevasse III), Camp 10B (continued)

Depth (cms) Below Aug. 27 Surface	Horizontal Ice Structures and Layer Boundaries	Remarks
165.1	6 mm ice stratum	
175.3	6 mm ice stratum	
180.4	6 mm ice stratum }	Grades to eastward into single ice stratum which thickens to 50 mm
182.9	6 mm ice stratum }	
196.9	1 to 2 mm ice lamina	
207.1	12 mm ice lamina	
210.9	12 mm ice lamina	Thickening and thinning
254.0	1 to 2 mm ice lamina	
259.1	6 mm ice stratum	
269.3	12 mm ice stratum	
271.8	6 mm ice stratum	Lensing in and out
284.5	6 mm ice stratum	
287.1	12 mm ice stratum	
301.0	6 mm ice stratum	
302.3	1 to 2 mm ice lamina	
322.6	Ice pods and lenses up to 12 mm	Irregular
340.4	25 mm ice stratum	
350.6	12 mm ice stratum	Lensing in and out
374.7	9 mm to 32 mm ice stratum	Thickening and thinning to dimensions noted, possibly '47-'48 ablation horizon
388.7	6 mm ice stratum	Thins out here and there
396.3	Sporadic ice pods	Lenticular and infrequent
403.9	Sporadic ice pods	Lenticular and infrequent
405.2	6 mm ice stratum	
411.5	5 thin ice laminae, the	Forming an icy zone
419.1	bottom one 9 mm thick	
429.3	1 to 2 mm ice lamina	
430.6	1 to 2 mm ice lamina, thickens to 25 mm	Slightly undulated (folded?) thickest to the east
439.5	9 mm ice stratum	2 ft. to eastward this stratum splits into two 6 mm ice strata
449.6	6 to 12 mm ice stratum	Thicker section toward east; diagonal ice vein, at 30° angle, trends upward to the 9 mm stratum at the 439.5 cm. level
459.7	1 to 2 mm ice lamina	
467.4	1 to 2 mm ice lamina	
482.7	12 to 25 mm ice stratum	Thicker section toward east

APPENDIX D

Pit C. (North side, Crevasse III), Camp 10B (continued)

Depth (cms) Below Aug. 27 Surface	Horizontal Ice Structures and Layer Boundaries	Remarks
492.8	25 mm ice stratum	Irregular, uneven top; flat base ('46-'47 ablation horizon?)
503.0	9 mm ice stratum	Lenses out to west
516.9	6 to 18 mm ice stratum	Irregular
520.7	Icy zone, myriad laminae grading eastward into solid ice stratum 100-125 mm thick (Thickest portion topped by an "ice column" which connected to the thick ice stratum at the 194 in. (492.8 cm) level)	Lenses out toward west to an ice stratum 25 mm thick
538.5	Layer of ice pods, up to 18 mm thick	Lenticular pods, 75-100 mm long; one block-shaped 50 mm thick and 50 mm long
543.6	Layer of ice pods	
563.9	37 mm ice stratum	Undulated at base; irregular top; coarse-grained crystals probably in '45-'46 ablation horizon
575.4	9 mm ice lens	
579.2	Double ice strata, 25 mm thick	Lensing in and out
596.9 609.6	Icy zone with 5 thin ice strata, up to 12 mm thick	Undulated, irregular, probably sun-cupped '44-'45 ablation horizon
612.1	6-50 mm ice stratum	Undulating
619.8	1-2 mm ice lamina	Irregular
622.3	3 ice lamina, each 1 mm	Each 12 mm apart
630.0	9 mm ice stratum	Lensing, irregular
640.1	Icy zone; 100-150 mm thick	

APPENDIX E.

1950 FIRN DENSITY RECORD, TAKU GLACIER

1. July 19, 1950; Pit A, Camp 10B, elevation 3575 ft.

Depth Below Ice Stratum at July 19 Névé Surface (cms)	Density gm/cm^3	Remarks
5.1	0.488*	Below 6-10 mm. ice stratum which was 50 mm. below névé surface
12.7	0.475*	Above 3 mm. ice stratum
22.9	0.475*	- - - -
30.5	0.479*	Just above 15 mm. ice stratum
35.6	0.481*	6 mm. below ice stratum
45.9	0.481	- - - -
55.9	0.472	In icy zone, 3 very thin ice laminae. Zone thickens to 150 mm. to westward.
66.1	0.437	Just below a very thin ice lamina
76.2	0.509	- - - -
86.4	0.543	Above 25 mm. ice stratum
94.0	0.458	- - - -
101.6	0.435	- - - -
109.3	0.477	2 very thin ice laminae
116.9	0.474	Below 2 very thin ice laminae
127.0	0.536	Just above ice laminae
134.8	0.557	Just above 15 mm. ice stratum
142.3	0.617	Just above 15 mm. ice stratum
149.9	0.530	Just above ice laminae
162.6	0.503	- - - -
167.7	0.562*	Just above ice lamina
172.8	0.576	- - - -
175.3	0.565	Just above 20 mm. ice stratum
177.8	0.525	Just below 6 mm. ice stratum
180.3	0.580	- - - -
188.0	0.588	- - - -
194.4	0.594	- - - -
203.2	0.591	- - - -
209.6	0.621	- - - -
218.5	0.619	- - - -
226.1	0.589	- - - -
236.3	0.587	- - - -
251.5	0.593	- - - -
261.7	0.610	- - - -
273.1	0.623	- - - -
284.5	0.598	- - - -
304.8	0.662	In icy zone(ice spicules & lenses), just above a 50 mm. ice stratum
317.5	0.610	No ice strata visible
325.2	0.605	Homogeneous very well-indurated firn.
335.3	0.627	
338.0	0.573	
358.1	0.634	
366.8	0.613	

*Indicates average of two samples.

APPENDIX E (continued)

II. July 22-23, 1950, Pit C-1 (Crevasse No. III), Camp 10B, elev. 3575 ft.

Depth Below July 22 Névé Surface (cms)	Density gm/cm³	Remarks
15.3	0.487	- - - -
30.5	0.437	- - - -
45.9	0.455	- - - -
61.0	0.493	- - - -
76.2	0.423	- - - -
91.5	0.412	- - - -
106.7	0.465	- - - -
122.0	0.525	- - - -
137.2	0.534	- - - -
152.4	0.556	- - - -
167.7	0.595	- - - -
182.9	0.616	- - - -
190.5	0.447	Schwimschnee (?) above 6-15 mm. ice stratum at '48-'49 ablation surface
195.6	0.635	Just below 6 mm. ice stratum
200.7	0.632	Just above 10 to 18 mm. ice stratum
207.1	0.600	Just below 10 to 18 mm. ice stratum
211.0	0.585	- - - -
224.8	0.623	- - - -
241.3	0.623	- - - -
270.6	0.630	Above ice stratum
275.6	0.654	- - - -
289.6	0.633	Above 15 mm. ice stratum
308.7	0.642	Above 2 mm. ice stratum
325.2	0.618	Above 20 mm. ice stratum
337.9	0.633	- - - -
355.6	0.625	- - - -
379.8	0.634	25 mm. above 15-20 mm. ice stratum
396.3	0.612	- - - -
409.0	0.678	25 mm. above 10-15 mm. ice stratum
426.8	0.637	25 mm. below 10-15 mm. ice stratum
444.5	0.645	Just above 6 mm. ice stratum
457.2	0.580	Just above 6 mm. ice stratum
473.8	0.620	Just below 6 mm. ice stratum
491.5	0.613	50 mm. below undulated dirty layer representing '47-'48 ablation surface. Ice laminae in sample.
515.7	0.628	25 mm. above 15 mm. ice stratum
529.6	0.685	Just below 15 mm. ice stratum

APPENDIX E (continued)

III. August 27, 1950, Pit C-2 (Crevasse No. III), Camp 10B, elev. 3575 ft.

All densities in this profile taken after three days of heavy rain

Depth Below Aug.27 Névé Surface (cms)	Density gm/cm3	Remarks
15.3	0.539	Last of 1949-50 firn
30.5	0.594	At top of 1948-49 firn pack in dirty layer zone
45.8	0.555	In 1948-49 firn
61.0	0.565	In 1948-49 firn
76.2	0.538	In 1948-49 firn
91.5	0.589	In 1948-49 firn
106.7	0.500	In 1948-49 firn
122.0	0.600	15 mm. below a 6-15 mm. ice stratum
137.2	0.630	In firn
152.5	0.582	Just above an icy zone of three ice strata
167.7	0.581	Ice lamina
183.0	0.597	Thin ice lenses
198.2	0.626	Between two thin ice laminae, basal one 10 mm. thick
213.5	0.624	Just below 6 mm. ice stratum
228.7	0.627	Just below 15 mm. ice stratum
244.0	0.581	25 mm. below 15 mm. ice stratum
259.2	0.664	15 mm. below three thin ice laminae in icy zone 50 mm. thick
274.5	0.681	- - - -
289.7	0.623	Just below icy zone with two 6 mm. ice strata
305.0	0.616	- - - -
320.2	0.653	- - - -
335.5	0.665	15 mm. below 20 mm. ice stratum
350.7	0.737	- - - -
366.0	0.660	Just above 6 mm. ice stratum in dirty zone of 1947-48 ablation horizon
381.2	0.699	- - - -
411.7	0.635	In icy zone, with three thin ice laminae, one in center is 6 mm. thick
442.2	0.719	50 mm. below an ice stratum and 25 mm. above an ice lamina
472.2	0.723	- - - -
503.2	0.718	75 mm. below 1946-47 ablation horizon
533.7	0.695	50 mm. below a 25 mm. ice stratum
564.2	0.700	Just below dirty zone of 1945-46 (?) ablation horizon; 50 mm. below a 50 mm. ice stratum
594.7	0.788	Just below several thick ice lenses and above a 15 mm. ice stratum (above 1944-45 undulated zone)
625.2	0.797	- - - -
655.7	0.841	Just above a 125-150 mm. ice stratum which in turn was just above dirty zone of 1943-44 (?) ablation horizon

APPENDIX E (continued)

Depth Below July 22 Névé Surface (cms)	Density gm/cm³	Remarks
548.7	0.670	25 mm. below 6 mm. ice stratum and above 25 mm. ice stratum
579.2	0.693	Below zone of ice stringers some 30 mm. thick
596.9	0.653	Just below a double 6 mm. ice stratum
609.6	0.722	Just above two 2 mm. ice strata 50 mm. apart and a dirty layer representing '46-'47 ablation surface
630.0	0.763	Above double ice strata of 15 and 20 mm.
650.3	0.796	Below 15 mm. ice lens
668.2	0.805	- - - -
687.1	0.755	20 mm. above a thick 50-75 mm. ice stratum lensing in places to 150-200. thickness (possibly at 1945-46 surface)
706.2	0.740	- - - -
725.2	0.730	Just below a 40 mm. ice stratum
740.5	0.786	50 mm. below a 15 mm. ice stratum (possible 1944-45 ablation level)
758.2	0.830	Just below 3 widely spaced 2 mm. ice laminae
778.6	0.850	Just above a 15 mm. ice stratum; below this is a 25 mm. ice pod; 50 mm. below this is a 40 mm. ice stratum, (possible ablation surface (?) at 789 mm.)
792.5	0.852	Just below 25 mm. ice stratum
807.8	0.779	Just below are three 6 mm. ice strata and above are two 6 mm. ice strata
823.0	0.780	Just below 15 mm. ice stratum
838.2	0.778	Just above 25-50 mm. ice stratum
853.5	0.809	Just above 10 mm. ice stratum
873.8	0.836	10 mm. ice stratum and in a 25 mm. icy zone
891.6	Dirt in core	Dirty zone representing late summer ablation horizon probably 1943-44; commences at 853 cm. level, but most prominent at 892 cm. level.

APPENDIX F

PERIODIC RECORD OF THE VERTICAL COMPONENT OF SURFACE WATER PERCOLATION

THROUGH THE FIRN

I. Pit A. Camp 10B (Elevation 3575 ft.)

Record from July 14 to July 27, 1950

(All values in cubic centimeters of water; values represent totals since previous time of record)
Depth of pan given in inches below the top of ice lamina at July 18 névé surface. Pan I, 25 in. below July 13 névé horizon.

Date July	Hour PST	Pan I 15 in.	Pan II 31 in.	Pan III 65 in.	Pan IV 100 in.	Pan V 96 in.	Pan VI 129 in.	Pan VII 129 in.
14	1920	placed						
15	1000	0	placed					
	1200	-	-					
	1600	100	220					
	1700	49	88					
	1800	43	88	placed				
	1900	32	73	1				
	2000	30	70	0				
	2100	82	25	0				
	2200	82	19	0				
	2300	9	46	0				
	2400	9	57	6.5				
16	1000	170	465	1				
	1100	43	62.5	0				
	1200	34	43	5				
	1300	38	60	0				
	1400	43	75	0	placed			
	1530	65	97	0	0			
	1600	24	30	0	0			
	1630	36	43	0	0			
	1700	40	43	0	0			
	1800	82	75	0	0			
	1830	38	40	0	0			
	1900	43	43	0	0			
	1930	54	60	0	0			
	2000	49	65	0	0			
	2030	67.5	91	0	0			
	2100	40	72.5	0	0			
	2130	49	75	0	0			
	2230	107	124	0	0			
	2300	57	62.5	0	0			
17	0700	(650+)*	(650+)*	0	0			
	0800	160	208	0	0			
	0900	198	198	0	19			
	1000	277.5	213	70	14			
	1100	256	225	67.5	14			

*All figures in parenthesis are minimum values from collection receptacles which over-flowed during interim between readings.

APPENDIX F

1. Pit A. (continued)

Date July	Hour PST	Pan I 15 in.	Pan II 31 in.	Pan III 65 in.	Pan IV 100 in.	Pan V 96 in.	Pan VI 129 in.	Pan VII 129 in.
17	1200	290	240.5	82	14			
	1300	280	256	97	14			
	1400	206	238	110	9			
	1500	?	203	94	11.5			
	1600	231.5	174	60	9			
	1630	-	-	-	-	placed		
	1700	182	171	91	6.5	0		
	1730	-	-	-	-	-	placed	
	1800	203	203	94	0	6.5	203	
	1900	122	144	60	1	147	280	
	2000	?	158	72.5	0	168	296	
	2100	166	149.5	57	0.5	147	256	
	2230	162	256	78	0.5	198	302	
	2330	91	128	43	0	103.5	142	
18	0700	768	956	256	2	(400+)	802	
	0800	34	67.5	30	6.5	30	54	
	0900	88	78	34	1	80	78	
	1000	203	117.5	0	0	82	75	
	1230	384	446.5	97	9	177	198	
	1330	128	193	54	0	85	78	
	1430	128	149.5	54	1.5	88	80	
	1530	115	252	75	1	94	88	
	1630	124	152	67.5	1	103.5	100	
	1730	128	38	70	0.5	115	115	
	1830	78	168	60	0	103.5	120	
	1930	38	103.5	40	0	80	85	
	2030	38	103.5	43	0	91	91	
	2115	-	-	-	-	-	-	placed
	2130	24	91	38	0	100	97	0
	2300	14	94	40	0	128	134.5	14
19	0800	54	316	128	1	(500+)	664	(500+)
	0915	24	36	16	1	49	65	49
	1000	34	30	21.5	2	34	49	34
	1130	97	52	32	1	54	91	0.5
	1230	82	57	34	0	43	75	49
	1330	78	78	36	1	38	62.5	43
	1500	128	182	70	0	60	128	70
	1610	70	34	60	1	60	128	16
	1700	52	110	67.5	0	49	85	60
	1805	49	128	43	0	72.5	85	75
	1900	30	91	0	0	70	85	70
	2000	24	91	52	0	88	110	80
	2100	11.5	62.5	34	1	72.5	78	11.5
	2200	16	72.5	38	1.5	85	97	75
	2300	11.5	57	30	0	70	80	57
	2400	1.5	43	24	0	60	75	49

APPENDIX F

I. Pit A. (continued)

Date July	Hour PST	Pan I 15 in.	Pan II 31 in.	Pan III 65 in.	Pan IV 100 in.	Pan V 96 in.	Pan VI 129 in.	Pan VIII 129 in.
20	0900	270	384	177	0	481	705	384
	1000	75	60	34	0	52	70	34
	1100	82	75	43	0	54	70	38
	1200	110	85	46	1	54	75	46
	1300	70	115	62.5	0	62.5	112.5	60
	1400	115	216	80	0	72.5	128	67.5
	1500	65	208	80	0	80	128	70
	1600	72.5	208	94	0	103.5	149.5	85
	1730	60	91	353	0	164	231.5	193
	1830	?	107	?	0	80	110	75
	1900	19	85	52	0	80	110	70
	2000	30	97	57	0	97	142	85
	2100	30	97	54	0	100	27	91
	2300	14	142	75	0	198	203	40
21	0800	270	558	260	0	(512+)	942	43
	0900	75	82	38	0	65	103.5	52
	1000	60	65	34	0	49	88	30
	1100	128*	91	85	0.5	54	-	?
	1130	-	-	-	-	-	reset**(VIA)	
	1200	158	115	60	0	54	-	-
	1300	65	152	75	0	49	14	62.5
	1400	14	182	80	0	54	0	85
	1500	11.5	225	97	0	85	0	19
	1800	21.5	615.5	272	1	310	9	411
	1910	46	177	103.5	0	139.5	0	128
	2100	1.5	231.5	75	0	193	0	166
	2200	1	78	36	0	82	0	75
	2300	1	75	43	0	103.5	0	110
	2400	0	45	28	0	62	0	59
22	0700	8	205	145	0	429	0	0
	0800	13	29	233	0.5	50	8	0
	0900	6	20	213	0	31	0	13
	1000	7	33	245	0	74	19	38
	1100	4	42	172	0	96	12	104
	1230	11	104	175	0	55	20	302
	1330	7	150	112	127	0	0	258
	1430	6	165	115	0	145	7	253
	1630	300	355	239	0	287	15	435
	1730	0	200	131	0	159	0	185
	1830	0	163	109	0	147	0	180
	1930	0	0	93	0	142	0	138
	2030	0	63	0	0	113	0	128
	2200	38	119	64	0	160	0	184

*Pan I beginning to be partially exposed to air

**Pan VI (hereafter referred to as Pan VIA) reset 30 in. to left at same level but 28 in. under prominent 3-in. (75mm.) ice stratum above Pan IV.

APPENDIX F

I. Pit A. (continued)

Date July	Hour PST	Pan I 15 in.	Pan II 31 in.	Pan III 65 in.	Pan IV 100 in.	Pan V 96 in.	Pan VIA 129 in.	Pan VII 129 in.
23	1000	1175	1148	375	7	(550+)	7	(750+)
	1230	585	445	145	8	180	10	168
	1500	685	560	250	1	292	2	328
	1700	465	500	200	0	263	6	313
	1900	353	385	172	56	299	0	330
	2100	523	407	122	57	232	0	261
	2300	232	327	147	0	204	0	0
24	0700	(600+)	(600+)	535	62	(600+)	0	0
	0900	272	251	107	0	208	0	0
	1200	369	303	195	0	286	0	282
	1500	325	500	242	0	265	0	324
	1800	348	631	289	6	18	0	?
	2100	175	382	218	75	337	4	0
25	0700	525	1124	550	83	550	0	750
	1000	285	512	242	0	283	0	0
	1300	348	656	344	14	298	9	6
	1400	82*	158*	132	44	113	2	192
	1500	122	219	56	45	110	3	156
	1600	155	231	74	76	136	1	197
	1700	136	252	73	85	145	1	186
	1800	119	168	55	55	3	2	138
	1900	165	228	36	54	111	0	157
	2000	97	145	34	25	82	0	115
	2100	108	168	43	26	109	2	140
	2200	132	189	34	16	95	0	124
26	0700	1185	(1200+)	321	141	(550+)	0	(750+)
	0900	258	338	45	0	124	4	155
	1200	400	490	135	0	168	0	237
	1300	207	288	70	0	83	7	107
	1600	(600+)	790	233	1	253	0	328
	1800	306	300	121	0	125	3	232
	2130	365	355	142	0	362	5	412
27	0700	(600+)	830	211	0	427	0	598
	1300	407	204	213	2	253	0	0
	1500	317	343	134	0	101	0	83

*Pans re-packed in firmer position at same place

APPENDIX F (continued)

II. Pit C. Camp 10B (Elevation 3575 ft.)

Intermittent record between July 29 and August 25, 1950

Depth of pan given in inches below the July 30-th névé surface

Date July	Hour PST	Pan VIII 16 in.	Pan IX 72 in.	Pan X 120 in.	Pan XI 190 in.	Pan XII 235 in.
29	1930	placed	placed			
	2030	230	136			
30	0700	232	511			
	0915	69	91			
	1100	73	72			
	1300	63	185	placed		
	1510	400	65	3		
	1600	-	-	-	placed	
	1700	212	54	1	0	
	1730	-	-	-	-	placed
	1900	177	74	0	0	307
	2100	152	80	0	0	388
	2200	54	34	2	2	178
	2400	94	65	0	0	294
31	0700	103	220	0	3	751
	1000	6	67	1	0	107
	1200	2	35	0	0	29
	1500	0	49	0	0	5
	1700	300	32	0	0	1
	2100	266	48	0	0	95
Aug.						
1	1000	1098	265	0	0	155
	1200	257	47	0	0	2
	1600	710	156	2	0	54
	1800	226	115	1	2	137
	2200	243	185	0	0	306
2	1000	540	467	1	1	554
	1200	24	50	0	0	24
	1600	465	102	0	0	11
	1900	378	56	0	0	83
3	1000	633	498	0	0	480
	1200	1	1	1	37	165
	1400	227	37	0	0	0
	1800	460	96	0	0	98
	2100	-	145	0	0	200

II. Pit C. (continued)

Date Aug.	Hour PST	Pan VIII 16 in.	Pan IX 72 in.	Pan X 120 in.	Pan XI 190 in.	Pan XII 235 in.
4	1100	470	446	0	0	82
	1300	145	36	0	0	2
	1500	148	37	1	2	3
	1700	165	34	0	0	2
	2100	263	65	0	0	1
18	1830	reset*(VIIIA)	-	-	-	-
	1930	-	155	-	-	-
	2030	96	152	0	0	0
	2130	89	72	0	0	0
	2300	96	114	0	0	0
19	0800	242	265	0	10	5
	1000	30	12	0	5	5
	1300	57	497	0	0	0
	1500	-	327	0	2	3
	1700	167	288	0	1	1
	1800	105	152	0	1	1
	1900	85	140	0	1	1
	2000	109	162	2	0	0
	2100	10	112	0	0	0
	2200	82	125	0	0	0
20	0900	81	752	0	2	2
	1000	81	92	0	0	0
	1200	99	418	-	-	-
	1300	0	1	0	-	-
	1500	0	0	0	-	-
	1700	143	0	0	0	0
	1800	138	0	0	0	0
	1900	155	0	0	0	0
	2000	112	119	0	0	0
	2100	62	66	0	0	0
	2200	65	73	0	0	0

*Pan VIII (hereafter referred to as VIIIA) reset 48 in. below July 3rd névé level, or 26 in. below Aug. 18th surface.

APPENDIX F

II. Pit C. (continued)

Date Aug.	Hour PST	Pan VIIIA 16 in.	Pan IX 72 in.	Pan X 120 in.	Pan XI 190 in.	Pan XII 235 in.
21	0800	360	225	-	-	-
	0900	15	1	-	-	-
	1000	17	1	-	-	-
	1100	15	68	-	-	-
	1200	9	243	-	-	-
	1300	20	36	-	-	-
	1400	24	238	-	-	-
	1500	52	60	-	-	-
	1600	80	1	-	-	-
	1700	93	87	-	-	-
	1800	93	76	0	-	-
	1900	70	0	0	-	-
	2000	79	0	0	-	-
	2100	0	0	0	-	-
	2200	47	0	0	-	-
25	1830*	-	-	-	-	-
	2030	600	800	0	0	0

Note: Depths of pans below August 29th firn surface: VIII, 11 in.; IX, 35 in; X, 83 in; XI, 153 in.; XII, 197 in.

*At 1830, horizontal component pan emplaced at same level as top of vertical component pan No. X. Subsequent observations from August 26th to 29th showed no horizontal flow in the firn at this level.

APPENDIX G

PERTINENT FIELD NOTES ON FIRN AND METEOROLOGICAL CONDITIONS AT CAMP 10B DURING PERIODS OF MELT-WATER RECORD IN PITS A AND C

(For supplementary micro-meteorological correlation, refer to daily three-hourly synoptic observations and continuous thermograph records in instrument shelter (Fig. 3, position 1) at Camp 10B. All temperature readings here noted are in degrees Fahrenheit. The ambient (amb.) air temperatures were taken four ft. above névé surface at the observation pit. The surface (surf.) air temperatures were obtained in the air layer five in. above the névé.)

Date July	Pertinent Notes - Pit A
14	No melt-water at 2000. 6000-ft. ceiling all day; 1500-ft. ceiling at night. Temp. (surf.) 35° at 2300. No crust.
15	4500-ft. ceiling in a.m. lowered to 500-1000 ft. in p.m. to 2000. Mist and light rain beginning at 2100. Temp. (amb.) 34° in evening; up to 42° in day. Usually no crust on surface at night from this date until September.
16	Fog all day. Relative humidity 98 per cent. At 1300 warm and heavy rain began causing considerable ablation. Between 1600 and 1950, 0.2 in. rainfall. Temp. (amb.) 37° during this period. Rain reduced slightly at 1930 but continued in hard downpour from 2020 to 2130. (amb. temp. 36°.) Between 1950 and 2200 0.17 in. of rainfall. At least 5 full hours of continuous rainfall in p.m. Heavy rain from 2230 to 2400. Draw pan records commenced at 1500.
17	Rain all night. Pptn. from 2200 on July 16th till 0700 on July 17th was 0.63 in. water. Top two pans (650 cc containers) observed to have overflowed at 0700. Ablation from 1400 on July 16th to 1300 on July 17th was 1 in. of firn. From 0700 to 0700 was 1-3/4 in. of which 3/4 in. firn ablation occurred during night (16-17) of heavy rain. Temp. (amb.) at 0700, 39°; at 1200, 40°. Pans 3 and 4 began to produce water at 1000 and 0900 respectively, indicating rain percolation had reached these levels about 19 hours after precipitation began. Heavy rain all morning. Between 0700 and 1000, 0.3 in. of rain at a rate of 0.1 in. per hour. Rain let up slightly at 1250. Light rain and fog in p.m. Temp. (amb.) 42°. Brighter, more sky radiation, although visibility never more than 300 yds. Rain stopped at 1500 and light rain and heavy fog again at 1600. Pptn. ceased at 1730. Temp. (surf.) 35°. Fine rain and fog until 1900; then heavy rain again. Temp. (surf.) 34° (amb.) 39°. Drizzle continued after 2100. Temp.(amb.) 36.5°: (surf.) 33.8°. At 2200, Temp. (surf.) 32°: (amb.) 34.7°. Light rain with dense fog at night.
18	Ceiling 1000 ft., fog and light rain in a.m. Temps. (amb.) and (surf.) were 39°. Clearing slightly by mid-afternoon. No rain from 1530 to 1830; then fine drizzle and mist until night-fall.

APPENDIX G

Pertinent Notes - Pit A (continued)

Date July	Pertinent Notes - Pit A
19	Minimum temps. during night; (amb.) 32° and (surf.) 31.9°. By 0800, Pans 5 and 7 had overflowed, each having collected in excess of 5000 cc since 2300 on the 18th. Overcast, 900-ft. ceiling at 0700. Dense fog, with visibility zero persisted until 1030. At 1130, fine mist thinning rapidly at 1145. Slight clearing at 1230. Intermittent and hazy sunlight all p.m.; no rain. Fog settled back on glacier by 1610. Maximum temp. (surf.) 53° in mid-p.m. due to radiation effects. Maximum temp. (amb.) 44°; by 1700 it was 39°. Dense fog and light rain in evening. (Temp. (amb.) 35.2°; (surf.) 32.1°.) Fog and light rain all night with minimum (amb.) temp. 33°.
20	Fog and rain since midnight. 0.38 in. firn ablation between 1400 on 19th and 0700 on 20th. Minimum temp. (amb.) during night 33°. At 0700, Temp. (amb.) 37°: (surf.) 31.9°. At 1100, steady rainfall, temp. (amb.) 40°. At 1200 medium heavy rain, clearing with intermittent light rain at 1300. Rain at 1400. Fine rain at 1730. Temp.(amb.) 36°: (surf.) 36°. At 1830, misty, no rain. Temp. 35° (amb. and surf.) Fog but no rain from 1900 on throughout the night. Temp.(amb.) 35° at 2000; 34° at 2100; 34° at 2300. Temp. (surf.) 33.2° at 2000; 32° at 2100 and throughout most of night.
21	0.16 in. precipitation since midnight. No rain in later a.m. Ablation 0.50 in. of firn during night. Clearing and colder. Temps.:at 0900, (amb.) 36°: (surf.) 34°. At 1000, (amb.) 35°, (surf.) 35°. Ceiling 7-10,000 ft. Sun shining brightly shortly after noon. CAVU all p.m. except for high cirrus from N.E. Temps.: (amb.) 41° 1500. At 1800, (amb.) 38.5°; (surf.) 37°. A 10- to 15 m.p.h. wind all p.m., (11 to 13 m.p.h. greater than at Camp 10.) Temperature difference of 20 degrees between 10B and 10. At 2100, Temp. (amb.) 37°; (surf.) 34°. At 2400, (amb.) 37.5°; (surf.) 34°.
22	CAVU all day until 1530; then cloudy, rain began at 2200. Pans became exposed fairly close to pit wall because of ablation. Therefore, these readings may be somewhat erratic. (This will be shown by analysis of the following factors in conjunction with melt-water records.) Direct solar heat on wall of Pans Nos. 6 and 7 at 0900. Average mid-morning temp.: (amb.) 39°; (surf.) 36°. At 1100, sun was off wall of Pans Nos. 1 to 5 and still on wall of Nos. 6 and 7. At 1230, sun on wall of Nos. 5, 6, and 7; but not on Nos. 1 to 4. Between 1100 and 1230, sun struck depth of Pan No. 7 for longest period; not on Nos. 5 and 6. At 1430, no sun on any of the pit walls, its rays just cut-off from Pan No. 7 at 1425. At 1630, high overcast forming, front moving in from S.W. with cold wind. By 1730, complete overcast at 13,000 ft. Temps. (amb.) 42°; (surf.) 36°. During day, Pans Nos. 1 and 2 settled slightly due to wall ablation, therefore not in close contact with ceiling of firn recess. This may explain markedly reduced values for Pans Nos. 1 and 2 from 1930 on, although (perhaps significantly) flow also ceased on Pan No. 3 at the 2030 and 2200 readings. Overcast all night. At 2200, temps. (amb.) 38°; (surf.) 34°.

APPENDIX G

Pertinent Notes - Pit A (continued)

Date July	Pertinent Notes - Pit A
23	Heavy rain and fog all day. At 1230, observed much dirty "fines" flushed into Pan No. 3 by persistent rain (probably from overlying '50 (?) dirty layer and ablation horizon). At 1500, much dirty material observed in Pans Nos. 3 and 5. Temp. (surf.) 39°. Low ceiling. At 1700, continuing heavy rain and mist. Temp. (surf.) 35°. At 1900, Temp. (amb.) 37°; light rain; visibility improved. At 1900, Temp. (amb.) 37°; light rain; visibility improved. At 2100, Temps. (amb.) 41°; (surf.) 34°. At 2300, temp. (amb.) 37°; (surf.) 33°.
24	Raining and complete overcast all day. At 0700, temp. (amb.) 38°. (surf.) 34°. At 0900, (amb.) 39°; (surf.) 36°. At 1200. (amb.) 41°; (surf.) 39°; at 1500, (amb.) 38°; (surf.) 36°. At 1800, (amb.) 36° (surf.) 35°; at 2100, (amb.) 35°; (surf.) 32°.
25	Complete overcast, rain. 0700, (amb.) 37°; (surf.) 34°. At 1000, (amb.) 41°; (surf.) 37°.
26	Complete overcast and rain with fog. At 0700, (amb.) 37°; (surf.) 34°. At 1200, (amb.) 39°, heavy rain. At 1300, (amb.) 38°. Heavy rain from 1600 until midnight.
27	Overcast, heavy rain. Air temperature abnormally high: (amb.) 46° most of day; (surf.) 40°. At 1500, (amb.) 41°; (surf.) 36°. Ceased records in Pit A at the 1500 readings on this date.

Pertinent Notes - Pit C

Date July	Pertinent Notes - Pit C
30	Fog in a.m. until 1100. Rain at 0700. Sun and intermittent fog until 1500. Fog in late afternoon until 1900. Temps.: at 0700 (amb.) 36°, (surf.) 33°; at 0915 (amb.) 36°, (surf.) 34°; at 1100 (amb.) 39°, (surf.) 35°; at 1300 (amb.) 42°, (surf.) 40°; at 1510 (amb.) 41.2°, (surf.) 37°; at 1900 (amb.) 34°, (surf.) 31.9°; at 2100 (amb.) 34°, (surf.) 31°.
31	Overcast in morning, clearing and sunny in afternoon. Temps.: at 0700 (amb.) 36°. (surf.) 32°; at 1000 (amb.) 37°.
Aug.	
1	Rain began during night and continued through the day.
2	Some rain during early a.m.; sunny in p.m.; clear and cool at 1900.
3	Warm during day; fog in a.m.; clear in early p.m. Cooler in evening with fog beginning at 1800.
4	Rain in early a.m. Fog at 1100 persisting all p.m.
18	Clear and cold in evening. crust on névé.
19	Clear and cold at 0800, crust on névé. Temp. at 1000, (amb.) 41°. Clouding up at 1300, overcast by 1500. Brief storm about 1700 with wind and rain for 30 minutes. Temp. at 1900, (amb.) 41°. Clear and cold in evening.
20	Sunny at 1000.

APPENDIX H

GLACIER STRUCTURES EXPOSED ON ICE LOBE, STATION 10C

I. Central Profile

Stratigraphic Zone Numbers*	Elevation at top of Layer (ft.)	Description	True Dip**	Slope Gradient	Slope Distance*** and Remarks
57	3968	Double dirty layer (s)	14°N.	10°S.	
56	3966	Double ice stratum	17°N.		
55	3965	Dirty layer			
54	3963	Double ice stratum	17°N.		
53	3961	Annual dirty layer			
52	3960	Heavy ice stratum			
51	3958	Prominent dirty layer; ice stratum below			
50	3955	Heavy ice stratum			
49	3954	Double ice stratum			
48	3952	Prominent dirty layer			
47	3946	Prominent close-spaced double dirty layer, with ice stratum below		15°S.	7 ft. between 47 and 46
46	3943	Prominent dirty layer			
45	3941	Four prominent ice strata	23°N.		
44	--	Two sets of prominent ice strata			
43	3938	Three sets of prominent ice strata			
42	3935	Prominent annual dirty layer			
41	--	Two sets of 3 ice strata			
40	3924-5	Dirty zone, 4 strata	27°N.		2 ft. between 40 and 39
39	3923	Thin dirty layer			4 ft. between 30 and 38
38	3919	Double ice strata	30°N.		
37	3918	Ice stratum with dirty layer below	30°N.	15°S.	9 ft. from 37 to 38
36	3916	Eight ice strata, dirty zone			
35	3910	Dirty layer and 3 ice strata			
34	--	3 ice strata			
33	3896	Dirty zone with prominent dirty layer above and below	30°N.		
32	3895	Dirty layer	34°N.		
31	--	Prominent dirty layer	32°N.	17°S.	
30	3886	Prominent dirty layer	40°N.		Englacial drainage conduit parallel to structure

Note: Elevations by micro-altimeter traverse, uncorrected
Underlined values represent definite annual dirty horizons

*Zone numbers in Parts I and II do not correspond

**Strike of beds, 090°T.

***Between designated zones

APPENDIX H

I. Central Profile (continued)

Strati-graphic Zone Numbers	Eleva-tion at top of Layer (ft.)	Description	True Dip	Slope Grad-ient	Slope Distance and Remarks
29	3885	Prominent dirty layer	33°N.		
28	3880	Double dirty layer (ice stratum below)			Thrust zone
27	--	Dirty layer			
26	3876	3 dirty strata in dirty zone	25°N.		
25	?	Thin dirty layer			
24	3862	Prominent dirty layer	25°N.		
23	--	Ice stratum			
22	--	Ice stratum			10 ft. between 21 and 22
21	3849	6 prominent straticulated ice strata with dirty layer at base	21°N.	18°S.	
20	3842	Ice stratum	24°N.		Thick serated ice zone be-tween 19 and 20
19	3838	Dirty layer with ice stratum below	22°N.		
18	3836	Ice stratum	18°N.		
17	--	Three ice strata	18°N.		
16	3828	Dirty zone			
15	3820	Dense icy zone	19°N.		
14	3817	Dirty layer, ice stratum below	21°N.		Dirty zone be-tween 14 and 13
13	3815	Dirty layer	16°N.		
12	3812	Moderately dirty layer			2 ft. from 12 to 11
11	3811	Prominent double ice strata	16°N.		
10	--	Dirty zone based by prominent dirty layer			
9	3810	Three close-spaced dirty layers	20°N.	25°S.	
8	--	Dirty layer	19°N.	22°-30°S.	Irregular slope
7	3809	Three ice strata, dirty layer below	19°N.		6 ft. between 7 and 6, rough surface
6	3805	Dirty zone, thin series of ice strata below			

APPENDIX H

I. Central Profile (continued)

Strati-graphic Zone Number	Elevation at top of Layer (ft.)	Description	True Dip	Slope Gradient	Slope Distance and Remarks
5	3788	15 ice strata, irregularly spaced, straticulated			Thrust-zone (?)
4	3746	Prominent dirty layer	17°N.?	25°S.	Lowest prominent dirty layer on lower slope. Many rock fragments on slope below this horizon
3	--	Ice stratum		25°S.	First appearance of ice strata on lower slope
2	3688	----		22°S.	1950 Névé surface (local firn limit, of mid-Aug., 1950)
1	3660	----		5-10°S.	1950 névé surface at base of slope

II. Eastern Profile

52	3907	Dirty layer	15°NW*	15°SE	4**
51	3906	Dirty layer			15
50	--	Dirty layer			3
49	--	Dirty layer	17°NW		8
48	--	Dirty layer	18°NW		6
47	--	Dirty layer			5
46	3894	Dirty layer		17°SE	10
45	--	Dirty layer	17°NW		7
44	--	Dirty layer			3
43	3889	Dirty layer			10
42	3884	Dirty layer	22°NW	19°SE	9
41	3881	Dirty layer with 3 prominent ice strata in zone below			14
40	--	Dirty layer with ice strata	26°NW		4
39	3875	Dirty layer, 2 prominent ice strata in zone below	30°NW		4
38	--	Dirty layer			2
37	3874	Dirty layer	32°NW		3

Note: Flevations by micro-altimeter traverse, uncorrected
Underlined values represent definite annual dirty horizons

*Strike of beds, 070°T.

**Slope distance to next figure (or dash) in column

APPENDIX H

II. Eastern Profile (continued)

Strati-graphic Zone Number	Eleva-tion at top of Layer (ft.)	Description	True Dip	Slope Grad-ient	Slope Distance and Remarks
36	--	Three prominent dirty layers in one zone			6; each 1 ft. apart
35	3870	Dirty layer and 3 ice strata below	32° NW	20° SE	13
34	--	Dirty layer and ice stratum			6
33	3865	Dirty layer and 5 straticu-lated ice strata	35° NW		6
32	--	Dirty layer			3
31	--	Dirty layer and 3 prominent ice strata			8
30	--	Double dirty layer	36° NW		2
29	3861	Thick dirty layer			2
28	--	Dirty layer and ice stratum			2
27	--	Double dirty layer			3
26	--	Triple close-spaced dirty layer	37° NW		3
25	3858	Prominent dirty layer with prominent ice stratum in zone below	40° NW	15° SE	5; just below 10C; top of 24 ft. zone analyzed for pollen
24	--	Dirty layer			3
23	3854	Bifurcated dirty layer	40° NW		4; truncated by thrust of 22
22	3853	Prominent dirt-laden thrust plane, with ice stratum in zone below; unconformity		16° SE	11; 8-in. scarp with subsidiary scarps in shingle or imbricate thrust pattern above
21	--	Prominent dirty layer with ice stratum above			3
20	3846	Prominent dirty layer with ice strata above and below	45° NW	12° SE	4; prominent 3-bed zone
19	--	Prominent dirty layer			5
18	3844	Prominent dirty layer with series of ice strata in zone below	43° NW		6

APPENDIX H

II. Eastern Profile (continued)

Stratigraphic Zone Number	Elevation at top of Layer (ft.)	Description	True Dip	Slope Gradient	Slope Distance and Remarks
17	--	Prominent dirty layer with ice stratum in zone below	45°NW		3
16	3841	Prominent dirty layer with ice stratum in zone below	45°NW		4
15	--	Dirty zone, 1 ft. thick			2
14	--	Dirty layer			2
13	3840	3 dirty layers with lower two forming a 3-ft. dirty zone just above 12.	48°NW	11°SE	6
12	3839	Dirty layer			5
11	3838	Dirty layer			7
10	3837	Dirty layer			2
9	3836	Dirty layer, 1 ft. thick	54°NW		6
8	3835	Dirty layer, ice stratum below	50°NW		4
7	3834	Dirty layer	50°NW		3
6	3833	3 thin dirty layers in zone below	50°NW		6
5	3832	Dirty layer	50°NW	12°SE	6
4	3830	Dirty layer with 6 stratriculated ice strata	50°NW		5
3	3827	Dirty layer	50°NW	10°SE	15; thrust zone?
2	--	Ice stratum in older recrystallized ice which is apparently being overridden		8°SE	39
1	3819	Rock outcrop on SE side of lobe near Station D			

APPENDIX I

LOG OF MECHANICAL CORE DRILLING, CAMP 10B, 1950

Date 1950	Depth Drilled (ft.) From	To	Notes and Record of Core Lengths at Listed Depths
3 Aug.	0	10	Commenced drilling in Drill Hole No. 1, with NX cross chopping star bit. Water level suddenly dripped in crevasse under deep well pump. Drilling proceeded without flushing water.
	10	16½	Changed to NX Double tube four-tooth bit on swivel barrel. Dry drilling. Inner tube filled with core from only 3½ ft. of drilling. When shifted to six-tooth bit the firn core became compacted and separated into alternating dense and broken segments of compression ice and firn.
	16½	18½	When core pulled the firn samples less compacted but still segmented. Samples appeared quite dry.
4 Aug.	18½	29	Employed three-tooth bit. Also Double tooth bit. Advance with short cores, each only 3 to 4 ft. (Still dry drilling down to 66 ft.)
	29	36	This 7 ft. drilled in 85 minutes (average 5 ft./hr.) Pressure on bit 1500 lbs. at 300 r.p.m. Core compressed into barrel was bent at points where it did not completely fill barrel.
	36	40	A 9½ ft. core drilled in 25 minutes (average 23 ft./hr.).
	40	44½	Total 4½ ft. cored in 30 minutes (9 ft./hr.). First 1.67 ft. in 30 seconds. Core length 10 ft. with the 4½ ft. advance.
	48½	52½	Firn, fairly dry.
	52½	56½	Firn, fairly dry.
	56½	60	Core length 9 ft. (with 3½ ft. advance); top portion of core sample wet; 1½ ft. dry; then 1 ft. wet and 4 ft. dry.
	60	62½	Drilled first 3-1/3 ft. in 36 seconds. Produced a 9½ ft. core (dry) in 2½ ft. advance

APPENDIX I (continued)

Date 1950	Depth Drilled (ft.) From	To	Notes and Record of Core Lengths at Listed Depths
4 Aug.	62½	66	Top 1 ft. wet; then 2½ ft. dry; 2 ft. wet; 1 ft. dry; bottom wet; (Dr. Bader suggested that this alternation of wet and dry firn layers is likely due to ice strata which did not show up in the core sample).
	66	70	NX Double tube, six-tooth core bit (to 94 ft. drilled dry with very short runs). Usually each run allowed a rapid advance at the top with the last few inches being very slow. (Actually this slow drilling at end of each run helped to prevent loss of the core when pulled out.)
5 Aug.	70	74	Top ½ ft. dry; coarse wet granular firn in bottom 3½ ft. Encountered an obstruction with slowed down drilling at 72 ft. probably a thick ice stratum.
	74	77½	Core of completely broken ice; probably a thick stratum or series of ice strata.
	77½	79½	Same as above
	79½	83	Rapid advance in wet firn
	83	87	Rapid advance in wet firn
	87	90	Rapid advance in wet firn
	90	94	Rapid advance in wet firn
6 Aug.	94	97	Core-bit stuck (somewhat) at 89 ft. level upon lowering it into drill hole. Core of wet firn.
	97	101	Wet firn
	101	108½	Wet firn
	108½	112	Wet firn
	112	116	Wet firn
	116	119½	Regularly spaced ice "monocles" with some (natural ice?) crystals up to 1½ in. diameter and containing oriented air bubbles.

Date 1950	Depth Drilled (ft.) From	To	Notes and Record of Core Lengths at Listed Depths
6 Aug.	119½	121	Drilled slowly with water for 6 in.; then 1 ft. for 5 minutes; then a rapid advance resulted without water. The core was lost but this rapid advance suggests that drilling still in firn. Commenced to install NX casing but unable lower it more than 25 ft. Pulled casing out. Made a four-tooth bit in casing coupling by means of a hack saw. Inside diameter of casing 3 in. Sawed teeth bent out 1/32 in.
7 Aug.			Completed cutting saw teeth in NX casing coupling. Used 20 ft. of NX casing for reaming barrel. Reamed hole to bottom, filling barrel two times while reaming. Water in hole at 110 ft.
	121	129-2/3	Drilled with casing barrel to 126½ft.; filling core barrel. Second run with regular NX-DT core barrel to 129-2/3 ft. and filled core barrel.
8 Aug.	129-2/3	136½	Water at 110 ft. in hole. Reamed hole to bottom with NX casing. Drilled dry with casing bit. Lowered 130 ft. of NX casing and filled casing with water. Water drained out of casing from below; lowering at rate of 5 in. per minute.
	136½	139½	Drilled with NX-DT core barrel, filling core barrel.
9 Aug			Water level in a crevasse at 67 ft. Casing pulled out; drill hole reamed to 139½ ft. with casing bit.
	139½	151	Disconnected deep well pump and moved it off crevasse. Pulled NX casing in drill hole; reamed to bottom, pulled out and then drilled to 150½ ft. with NX casing coupling bit. Very slow advance (slightly less than 6 ft. in one hour). Apparently in solid ice well below firn cover. Worked drill bit at 300 r.p.m. and 1500 lb. pressure. On pulling casing up it stuck at 65 ft. (slush floating on water?). Lowered rods to bottom and commenced reinsert NX casing to 44 ft.

APPENDIX I (continued)

Date 1950	Depth Drilled (ft.) From	To	Notes and Record of Core Lengths at Listed Depths
10 Aug.	150½		No progress; casing lowered to 74 ft. over drill rod, ramming through obstruction. Casing barrel hoisted up against casing and both lifted together. Lowered full length of NX casing to 150½ ft.
11 Aug.	150½	151½	Water level in casing down 39 ft. in hole. Casing also pressure melted in 1-3/8 in. Drilled with water for 1 ft. Obtained good core of pitted but clear ice.
	151½	157	Drilled with water to 156½ ft., water pressure 45 lb.; 300 r.p.m.; advance 6 in. per minute. Lost water before run was finished. (Return water stopped after a few minutes of drilling and water level in casing dropped rapidly) 50 in. ice core recovered in pieces up to 6 in. long. Water in crevasse under deep well pump again drained out. (Probably due to further adjustment in crevasse system and draining of perched water table.)
12 Aug.	157	161	Water level in crevasse at 73 ft. Drilled dry at rate of 1 ft. 1½ in. per minute; core broken. Pulled up NX casing. Added 10 ft. and lowered by force of lifting and dropping whole string of casing. Found that casing had unscrewed at 110 ft. since core barrel stopped at the 110 ft. level when lowered through casing. Unscrewing likely took place when water was lost from hole on 11 Aug. Pulled out 110 ft. NX casing. 40 ft. of casing left in bottom of hole.
13 Aug.	161	165	Spent day trying to "fish" for bottom 40 ft. of (lost) casing. All efforts in vain, so lowered rods with core barrel and made two runs without water to 165 ft.
14 Aug.	165	181-3/4	Further attempts to "fish" out casing failed. Continued drilling without casing since it was found possible to insert core barrel to bottom of hole. Poor core sample due to lack of water. (Made a 1 ft. run without water; then two runs with water to 178½ ft. and one more run without water to 181-3/4 ft. Drilling done with less than 30 lbs. pressure; at 250 r.p.m. and 2¼ in. per minute; rate without water only ½ in. per minute.)

APPENDIX I (continued)

Date 1950	Depth Drilled (ft.) From	To	Notes and Record of Core Lengths at Listed Depths
15 Aug.			Water returned into crevasse at 65 ft. Re-located deep well pump and put it in operation.
	181-3/4	187½	Drilled with water. Bad core.
	187½	196	Drilled with water. 9 ft. core; with top 1 ft. poor. Rest of core was perfect, pieces 6½ in. long. Longest piece 8 in. (Drilled at 60 lbs. pressure, 250 r.p.m. and 5 min. per ft.) Pumped water into surface storage supply until 11 P.M. Storage consisted of tarpaulins dug into firn.
16 Aug.			All drilling with water, at 300 r.p.m. and 60 lbs. water pressure. Rod pressure 1000 lb. Average 6 min. per ft. drill rate. Used NX-DT four and six-tooth bits.
	196	206	Core slightly bent (barrel was full). Bottom 3 ft. perfect, upper section broken.
	206	215	Good core 3-6 ft. from bottom; rest broken up.
	215	224	Top 2 ft. good core; bubbly ice, 1½ ft. good core, clear ice, quite free of bubbles. 3 ft. bad core, 2 ft. good core, bubbly ice with clear bands. 2 ft. bad core.
	224	232	All but 3 ft. of core lost. Top 1 ft. good core; very coarse bubbles in ice. 1 ft. good core, smaller bubbles. 1 ft. bad core.
	232	241	Drilling consumed 8 gal. of water per minute. Top 4 ft. good core, clear bubbly ice; 4 ft. bad core. 2 ft. good core in one piece of exceptional length.
17 Aug.			Note: Lost casing (40 ft.) had sunk 13 ft. in 3 days, into lower part of drill hole which was drilled subsequent to the unscrewing of this casing.
			All drilling with water at 60 lbs. pressure and 200-250 r.p.m. Rate of 10 ft./hr. Used NX-DT three and four-tooth bits.

Date 1950	Depth Drilled (ft.) From	To	Notes and Record of Core Lengths at Listed Depths
17 Aug.	241	249	Whole core good. Pieces ½ ft.-1 ft. Top 5 ft. clear bubbly ice with some bubbles up to 5 mm. 1 ft. clear bubble-free ice. 4 ft. clear bubbly ice, bubble size 1-2 mm.
	249	258	Top 4 ft. clear, bubbly, large bubbles. 1 ft. with very large bubbles (6-9 mm.). One side of core, clear in middle and bubbles 1-3 mm. on other side of core. 1 ft. clear bubble free. Rest broken up to resemble firn.
			Note: This is an important core since it proves that Rotation of bit does not cause rotational deformation of cores of ice.
	258	266	Top 6 ft. good core, with pieces 16-18 in. long, very homogeneous, clear bubbly, bubbles 2 mm. very regularly distributed. 2 ft. broken up.
	266	274½	Top 3½ ft. clear bubbly with a bubble free 4 in. band at 3 ft. Bubbles small at top getting progressively larger downwards. Rest of core broken up.
18 Aug.			NX-DT four-toothed bit, with 60 lbs. pressure at 250 r.p.m.; rate of 10 ft. per hour.
	274½	283-3/4	Top 3½ ft. of good core; clear bubbly and with narrow ice strata (max. 1 in.) nearly bubble free. 2-4 strata per ft. in irregular distribution. Rest broken up.
	284	292	Top 18 in. clear bubbly; bubbles smaller and less numerous than usual. Rest broken up.
			Note: At this depth unexpected difficulty encountered. The 40 ft. of lost casing, which had been left unthreaded and hanging in the drill hole, dropped down and hit a second 10 ft. length of casing which had previously come loose and settled to the 238 ft. level. (Bottom of 10 ft. length.) The 40 ft. length jammed so tightly against the lower section and in such a manner that it was impossible to pass the drill rod and core barrel down through the top of the bottom piece.

Date 1950	Depth Drilled (ft.) From	To	Notes and Record of Core Lengths at Listed Depths
19 Aug.			All "fishing" efforts unsuccessful. Thus the core barrel could not penetrate deeper than 282 ft. and drilling had to cease. All efforts were made to rectify the situation. Dropping sand into the top of the 40 ft. length, in hopes that the sand might settle through the maze of ice cuttings concentrated at the water table, was to no avail. A new hole was therefore begun. What actually happened was that in the process of drilling through the lost casing in the few days before its lower 10 ft. had become unscrewed, it separated and dropped farther into the hole. Then the two sections, when they became joined again, were irregularly jammed together so that the hole became completely blocked.
20 Aug.			Commenced cutting threads on 2 in. I.D. aluminum pipe and lowered 230 ft. (coupled in 10 ft. water-tight sections) into drill hole. (15 ft. subsequently added to top of pipe to prevent its burial by winter snow.) Thus total length 245 ft., 15 ft. of which extended above wooden platform. Top of this pipe used as future reference horizon.
21 Aug.			Commenced to survey aluminum pipe in Hole No.1, Using Eastman Oil Well Survey instrument. Found hole vertical to 1°10'. (see plotted results of 22 Aug.).
22 Aug.			Completed survey of vertical aluminum pipe. Reoriented drill machine and tripod for drilling new hole 5 ft. to south.
23 Aug.	0	1-1/3	Commenced drilling on Hole No.2. Used NX casing for core barrel. Drilling <u>without</u> water.
	1-1/3	3	
	3	7	
	7	11	
	11	20	
	20	30	
	30	40	
24 Aug.	40	43½	Drilled with NX-DT core barrel without water. at 54½ ft. to 61½ ft. found an opening of 7 ft.
	43½	61½	
	61½	65½	
	65½	69½	
	69½	73½	
	73½	77½	

APPENDIX I (continued)

Date 1950	Depth Drilled (ft.) From	To	Notes and Record of Core Lengths at Listed Depths
25 Aug.	77½	91½	Rods unscrewed at 54 ft. level leaving core barrel with 30 ft. of A rods in hole. Lowered NX casing, and hammered it down to 59 ft. Could not get it over drill rod. Put rods in and didn't feel them till 65 ft. (side of rod).
	91½	94	
26 Aug.			Pulled rods and casing out, moved drill machine over 4½ ft.-5 ft., also moved tripod and started Hole No. 3 4½ ft. to west.
	0	1-3/4	Used NX casing for core barrel. Put deep well pump in running order again.
	1-3/4	3½	
	3½	7	
	7	11	
	11	20	
27 Aug.	20	30	NX casing as core barrel. NX-DT core barrel, six-toothed bit used. Ran deep well pump, but drilled without water.
	30	35	
	35	40	
	40	45	
28 Aug.	45	50	NX-DT Drilling, but not saving core for sample. Sample taken at 59 ft. Drilled without water.
	50	55	
	55	60	
	60	65	
	65	70	
29 Aug.	70	75	Drilled with water, at 60 lbs. pressure.
	75	80	
	80	84	
30 Aug.	84	91	Drilled with water
	91	96	Drilled with water
	96	102	Drilled without water
31 Aug.	102	108	NX-DT six-tooth bit and without water
	108	114	
	114	120	
	120	124	
1 Sept.	124	130	NX-DT without water
	130	139	NX-DT with water
	139	146	" " "
	146	151	" " "
2 Sept.	151	157½	NX-DT drilled with water. NX-DT started drilling with water; ran out at 162 ft.
	157½	164	
	164	170	NX-DT drilled without water.
	170	175	
3 Sept.			Took out deep well pump; rods and casing. Rigged down drill set.

APPENDIX J

RECORD OF SURVEY

DATE August [illegible], 1950   Single Shot [illegible]

	MEASURED DEPTH	DRIFT ANGLE	TRUE VERTICAL DEPTH	COURSE DEVIATION	DRIFT DIRECTION	NORTH	SOUTH	EAST	WEST	REMARKS
1	15.00	0° [illegible]	15.00	0.00	VERTICAL		-		-	
2	[illegible].00	0° 10'	[illegible].00	0.08	S [illegible]° W		[illegible]		[illegible]	
3	[illegible].00	0° [illegible]'	[illegible].00	0.[illegible]	S [illegible]° W		[illegible]		[illegible]	
4	[illegible].00	0° [illegible]'	[illegible].00	0.[illegible]	S [illegible]° W		[illegible]		[illegible]	
5	102.00	1° 10'	102.00	0.41	S 75° W		[illegible]		97	
6	[illegible].00	1° 00'	[illegible].00	0.35	S [illegible]° W		[illegible]		1.[illegible]	
7	[illegible].00	1° 05'	[illegible].00	0.[illegible]	S [illegible]° W		[illegible]		[illegible]	
8	[illegible].00	1° [illegible]'	[illegible].00	0.35	S [illegible]° W		[illegible]		[illegible]	
9	[illegible].00	1° [illegible]'	[illegible].00	0.[illegible]	S [illegible]° W		[illegible]		[illegible]	
10	[illegible].00	1° 05'	[illegible].00	0.[illegible]	S 55° W		[illegible]		[illegible]	
11	[illegible].00	1° 05'	[illegible].00	0.58	S 60° E		1.04		[illegible]	
12	[illegible].00	1° 05'	[illegible].00	0.58	S 04° E		1.[illegible]		[illegible]	
				CLOSURE 2.68'	S 57° 58' W					
13	245.00	1° 05'	245.00	.06	S 04° E		1.48		2.27	[illegible]
			245 ft.	CLOSURE 2.71	S 56° 54' W					

DATE February 11 and 12, 1952

	MEASURED DEPTH	DRIFT ANGLE	TRUE VERTICAL DEPTH	COURSE DEVIATION	DRIFT DIRECTION	NORTH	SOUTH	EAST	WEST	REMARKS
1	● 18.00	0° [illegible]'	18.00	0.15	N 87° 00' E	01		15		
2	25.00	0° 45'	25.00	0.07	S 87° 00' E	01		[illegible]		
3	43.00	0° [illegible]'	43.00	0.25	S 85° 00' E		33	[illegible]		
4	● 55.00	0° 15'	55.00	0.05	S 30° 00' W		17	[illegible]		
5	63.00	0° 35'	63.00	0.08	S 57° 00' W		[illegible]	[illegible]		
6	83.00	1° 46'	[illegible].99	0.61	S 75° 00' W		37		43	
7	● 95.00	2° 00'	94.98	0.42	S 68° 00' W		57		80	
8	10[illegible].00	[illegible]	1[illegible].98	[illegible]	S 45° 00' W		77		1.00	
9	● 11[illegible].00	1° 30'	111.98	0.31	S [illegible]° 00' W		73		1.31	
10	123.00	1° 35'	122.98	[illegible]	S 87° 00' W		78		1.53	
11	● 131.00	0° 55'	[illegible].98	0.13	S 86° 00' W		73		1.66	
12	● 135.00	1° 00'	1[illegible].98	0.07	S 79° 00' W		[illegible]		1.73	
13	143.00	0° 50'	142.98	0.12	S 86° 00' W		75		1.85	
14	165.00	[illegible] 00'	168.97	0.38	S 44° 00' W		[illegible]		2.03	
15	● 175.00	1° 00'	174.97	0.[illegible]	S 77° 00' W		[illegible]		2.43	
16	183.00	1° 05'	182.97	0.15	S 74° 00' W		[illegible]		2.57	
17	209.00	1° 05'	208.96	0.38	S 21° 00' E		53		2.43	
18	● 215.00	1° 00'	211.96	0.23	S 70° 00' E		46		2.21	
19	223.00	1° 05'	222.96	0.15	S 10° 00' W		60		2.24	
20	● 235.00	1° 10'	234.96	0.24	S 81° 00' W		64		2.48	
21	● 239.00	1° 25'	238.96	0.10	S 52° 00' E		70		2.40	
22	● 242.00	1° 10'	241.96	0.06	S 42° 00' E		74		2.36	
23	243.00	1° 20'	242.96	0.02	S 46° 00' E		75		2.35	
			243 ft.	CLOSURE 2.47	S 72° 18' W					
24	● 245.00	1° 20'	244.96	.05	S 46° 00' E		78		2.31	[illegible]
				CLOSURE 2.44	S 71° 21' W					

DATE June 12, 1952

	MEASURED DEPTH	DRIFT ANGLE	TRUE VERTICAL DEPTH	COURSE DEVIATION	DRIFT DIRECTION	NORTH	SOUTH	EAST	WEST	REMARKS
1	15.00	0° 25'	15.00	.11	S 60° 00' E		.06	.10		
2	30.00	0° 20'	30.00	.09	S 37° 00' W		.13	.05		
3	45.00	0° 20'	45.00	.09	S 15° 00' W		.22	.03		
4	60.00	0° 30'	60.00	.13	S 30° 00' W		.32		.05	
5	75.00	1° 40'	74.99	.44	S 66° 00' W		.50		.45	
6	90.00	3° 00'	89.97	.78	S 79° 00' W		.65		1.22	
7	105.00	3° 00'	104.95	.78	N 33° 00' W		.55		1.99	
8	120.00	1° 00'	119.95	.26	N 55° 00' W		.40		2.20	[illegible]
9	135.00	0° 40'	134.95	.17	West		.40		2.37	
10	150.00	1° 10'	149.95	.31	West		.40		2.68	
11	165.00	1° 05'	164.95	.28	S 77° 00' W		.46		2.95	
12	180.00	1° 10'	179.95	.31	S 80° 00' W		.51		3.26	
13	195.00	1° 00'	194.95	.26	S 67° 00' W		.61		3.50	
14	210.00	1° 25'	209.95	.37	S 78° 00' E		.53		3.14	
15	225.00	1° 10'	224.95	.31	East		.53		2.83	
16	240.00	1° 30'	239.95	.39	S 16° 00' E		.90		2.72	[illegible]
			240 ft. CLOSURE	2.87	S 71° 42' W					

DATE September 14, 1952

	MEASURED DEPTH	DRIFT ANGLE	TRUE VERTICAL DEPTH	COURSE DEVIATION	DRIFT DIRECTION	NORTH	SOUTH	EAST	WEST	REMARKS
1	5.00	2° 00'	5.00	.17	N 49° 00' W	.11			.13	
2	25.00	1° 00'	25.00	.35	S 61° 00' W		.06		.44	
3	45.00	0° 45'	45.00	.26	N 65° 00' W	.05			.68	
4	65.00	2° 40'	64.98	.93	S 75° 00' W		.19		1.58	
5	85.00	7° 15'	84.82	2.52	S 41° 00' W		2.09		3.23	
6	95.00	4° 00'	94.80	.70	N 69° 00' W		1.84		3.88	
7	105.00	1° 00'	104.80	.18	N 39° 00' W		1.70		3.99	
8	115.00	0° 55'	114.80	.16	N 57° 00' E		1.61		3.86	
9	125.00	2° 00'	124.79	.35	N 75° 00' W		1.52		4.20	
10	135.00	2° 30'	134.78	.44	N 82° 00' W		1.46		4.64	
11	145.00	2° 00'	144.77	.35	N 89° 00' W		1.45		4.99	
12	165.00	1° 40'	164.76	.58	S 87° 00' W		1.48		5.57	
13	185.00	2° 00'	184.75	.70	S 54° 00' E		1.89		5.00	
14	205.00	1° 40'	204.74	.58	S 33° 00' W		2.[illegible]		5.32	
15	223.00	2° 00'	222.73	.63	S 13° 00' E		[illegible].99		5.18	
	245.00									[illegible]
			[illegible] Closure	5.9[illegible]	S [illegible]° 00' W					

● [illegible]

APPENDIX K - 1 JUNEAU ICE FIELD RESEARCH PROJECT

Camp Number 10 Month June Year 1950 Elevation 5062 ft.

Date	Maximum Temperature	Minimum Temperature	Mean Temperature	Average Cloudiness	Total Precipitation	Total Snowfall	Average Wind Speed	Average Wind Speed Night	Average Wind Speed Day	Average Wind Direction	Days With Fog	Ablation	Average Relative Humidity	Amount of Sunshine hrs & mins.
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														
21														
22														
23	[illegible]	46	[illegible]	3	T	0	-	-	-	-		-	[illegible]	
24	[illegible]	[illegible]	[illegible]	10	T	0	-	-	-	E		-	90	0:00
25	[illegible]	37	[illegible]	10	.25	0	-	-	-	E	X	-	100	0:00
26	60	[illegible]	50	5	0	0	-	-	-	[illegible]		-	81	-
27	[illegible]	[illegible]	47	6	[illegible]	0	-	-	-	[illegible]		-	[illegible]	-
28	66	43	55	9	[illegible]	0	-	-	-	[illegible]		-	[illegible]	2:37
29	[illegible]	40	[illegible]	8	[illegible]	0	-	-	-	[illegible]		-	86	2:55
30	56	[illegible]	48	5	[illegible]	0	-	-	-	E		-	87	5:57*
31														
SUM														
MEAN														

BY USWB JUNEAU ALASKA

*Minimum value due to improper adjustment of recorder

APPENDIX K - 2 JUNEAU ICE FIELD RESEARCH PROJECT

Camp Number 10 Month July Year 1950 Elevation 5062 ft.

Date	Maximum Temperature	Minimum Temperature	Mean Temperature	Average Cloudiness	Total Precipitation	Total Snowfall	Average Wind Speed	Average Wind Speed Night	Average Wind Speed Day	Average Wind Direction	Days With Fog	Ablation	Average Relative Humidity	Amount of Sunshine hrs & mins.
1	57	36	47	2	0	-				E	-	-	74	10:47*
2	64	38	51	9	.17	-				E	-	-	79	5:52
3	60	37	48	5	0	-				E	-	-	74	6:54*
4	67	43	55	8	0	-				[illegible]	-	-	59	11:32*
5	54	37	46	10	.22	-				E	X	-	98	0:00
6	43	33	38	10	.06	-				E	X	-	100	0:00
7	49	32	41	7	.08	-				W	X	-	91	0:00
8	59	35	47	3	0	-				[illegible]	-	-	55	12:10*
9	63	47	55	4	0	-				E	-	-	50	10:12
10	63	45	54	1	0	-				[illegible]	-	-	54	12:[illegible]*
11	53	41	47	10	0	-				E	X	-	90	0:00
12	48	38	43	10	.19	-				E	X	-	100	0:00
13	60	38	49	8	.07	-				E	X	-	85	8:09*
14	53	37	45	10	.02	-				E	-	-	79	0:00
15	54	40	47	10	T	-				E	X	-	95	0:00
16	44	38	41	10	.46	-				E	X	-	100	0:00
17	47	39	44	10	1.05	-				E	X	-	100	0:00
18	51	39	45	10	.64	-				E	X	-	100	0:00
19	51	37	44	10	0	-				E	X	-	99	0:00
20	47	38	43	10	.36	-				E	X	-	100	0:00
21	64	40	52	7	.08	-				W	-	-	74	5:16*
22	[illegible]	[illegible]	[illegible]	7	T	-				SW	-	-	64	9:35
23	54	44	49	10	.68	-				E	-	-	98	0:00
24	52	42	47	10	.70	-				E	-	-	100	0:00
25	53	43	48	10	.37	-				E	-	-	95	0:00
26	47	36	42	10	.59	-				[illegible]	X	-	100	0:00
27	47	31	44	10	.36	-				E	-	-	91	0:00
28	47	36	46	10	T	-				[illegible]	-	-	97	0:00
29	45	36	41	10	.93	T				[illegible]	X	-	99	0:00
30	47	35	41	10	.12	-				[illegible]	X	-	98	0:00
31	51	34	43	10	T	-				[illegible]	X	-	84	2:09
SUM	1657	1195	-	261	6.95	T				-	14	-	2680	
MEAN	53.5	38.5	46.0	8.4	-	-				E			86	

BY USWB JUNEAU ALASKA

*Minimum value due to improper adjustment of recorder

APPENDIX K - 3 JUNEAU ICE FIELD RESEARCH PROJECT

Camp Number [illegible] Month August Year 1950 Elevation [illegible] ft.

Date	Maximum Temperature	Minimum Temperature	Mean Temperature	Average Cloudiness	Total Precipitation	Total Snowfall	Average Wind Speed	Average Wind Speed Night	Average Wind Speed Day	Average Wind Direction	Days With Fog	Ablation	Average Relative Humidity	Amount of Sunshine hrs & mins.
1	48	36	48	10	.74	0				[illegible]	-	-	100	4:08
2	53	34	43	10	.13	0				[illegible]	-	-	97	0:34
3	51	37	44	10	0	0				W	X	-	95	0:09
4	46	35	41	9	.07	0				[illegible]	X	-	95	0:52
5	54	35	45	8	.14	0				N	-	-	71	8:18
6	55	38	47	4	0	0				[illegible]	-	-	64	11:04
7	60	42	51	7	0	0				N	-	-	51	10:57
8	61	45	53	8	0	0				N	-	-	45	12:40
9	65	51	58	1	0	0				N	-	-	43	12:45
10	70	50	60	5	0	0				[illegible]	-	-	51	11:37
11	78	52	65	4	0	0				[illegible]	-	-	58	13:17
12	69	39	54	7	0	0				E	-	-	47	8:39
13	65	34	50	8	.02	0				E	-	-	95	6:21
14	[illegible]	31	44	1	0	0				W	-	-	76	11:25
15	55	30	42	0	0	0				W	-	-	-	13:07
16	56	42	49	0	0	0				[illegible]	-	-	-	13:09
17	65	39	52	1	0	0				[illegible]	-	-	91	12:58
18	71	51	61	0	0	0				[illegible]	-	-	80	13:06
19	66	36	50	6	T	0				[illegible]	-	-	66	6:44
20	64	42	55	3	0	0				[illegible]	-	-	74	10:27
21	65	47	56	1	0	0				S	-	-	74	12:42
22	62	45	54	3	0	0				[illegible]	-	-	77	6:05
23	65	46	56	10	T	0				[illegible]	-	-	92	12:12
24	[illegible]	38	45	9	.55	0				[illegible]	X	-	90	4:46
25	44	37	42	10	2.18	0				E	X	-	100	9:19
26	44	36	40	9	1.50	0				E	X	-	97	0:00
27	40	35	37	10	1.64	0				[illegible]	X	-	100	0:00
28	38	32	35	10	1.15	T				[illegible]	X	-	100	0:00
29	39	31	35	10	.25	T				[illegible]	X	-	100	0:00
30	49	31	40	9	.50	0				N	X	-	97	0:00
31	53	33	43	8	0	0				W	-	-	68	0:00
SUM	1754	1187		186	8.50	T					9		1505	
MEAN	56.6	38.9	47.8	6.0						[illegible]			7.8	

BY USWB JUNEAU ALASKA

*Minimum value due to improper adjustment of recorder

(c)

APPENDIX K - 4 JUNEAU ICE FIELD RESEARCH PROJECT

Camp Number 10 Month September Year 1950 Elevation 3862 feet.

Date	Maximum Temperature	Minimum Temperature	Mean Temperature	Average Cloudiness	Total Precipitation	Total Snowfall	Average Wind Speed	Average Wind Speed Night	Average Wind Speed Day	Average Wind Direction	Days With Fog	Ablation	Average Relative Humidity	Amt. of Sunshine hrs & mins.
1	49	32	41	10	.84	0				SE	X	-	100	0:00
2	45	33	39	9	.73	0				SE	X	-	94	0:00
3	44	31	38	9	.40	0				SE	X	-	100	0:00
4	55	30	43	10	.36	0				[illegible]	X	-	100	0:00
5	38	30	34	10	.70	1.0				[illegible]	X	-	100	0:00
6	47	30	39	9	0	0				[illegible]	-	-	88	3:34
7	48	33	41	7	.25	0				SW	X	-	84	7:27
8	53	34	44	4	0	0				SE	-	-	60	10:47
9	58	42	50	10	0	0				S	-	-	67	0:00
10	54	47	51	10	.09	0				SE	X	-	98	0:00
11	46	35	41	6	.05	0				0	X	-	91	4:46
12	58	37	48	1	0	0				0	-	-	65	10:20
13	66	45	56	0	0	0				0	-	-	44	10:04
14	64	41	53	7	0	0				[illegible]	-	-	78	10:12
15	48	34	41	8	0	0				SE	X	-	85	0:00
16	49	33	41	3	0	0				N	-	-	80	9:50
17	39	34	37	10	.20	0				SE	X	-	100	0:00
18	43	33	38	10	.86	0				SE	X	-	95	0:00
19	42	37	40	10	1.61	0				SE	X	-	100	0:00
20	42	32	37	10	1.96	T				SE	X	-	100	0:00
21	48	30	39	10	1.18	T				SE	X	-	100	0:00
22	47	31	39	10	1.95	T				[illegible]	X	-	100	0:00
23	38	31	35	10	.68	1.0				S	X	-	100	0:00
24	36	30	33	10	2.00*	6.0				SE	X	-	100	0:00
25	42	31	37	10	1.25	1.0				[illegible]	X	-	97	0:00
26	42	27	35	9	0	0				[illegible]	-	-	86	5:34
27	44	27	36	8	T	T				S	-	-	92	4:13
28	43	25	34	7	0	0				[illegible]	-	-	79	8:46
29					0									
30					0									
31														
SUM	1332.8	955		227	13.61	9.0					18		2477	
MEAN	47.4	33.4	40.4	8.1						[illegible]			88.5	

BY USWB JUNEAU ALASKA

* Estimated

Incomplete

APPENDIX L - 1 JUNEAU ICE FIELD RESEARCH PROJECT

Camp Number 10B Month July Year 1950 Elevation 3575 feet.

Date	Maximum Temperature	Minimum Temperature	Mean Temperature	Average Cloudiness	Total Precipitation	Total Snowfall	Average Wind Speed	Average Wind Speed Light	Average Wind Speed Day	Average Wind Direction	Days with Fog	Ablation*	Average Relative Humidity
1													
2												1.50	
3	45.0	34.0	40.0	0.8	.03	0	6.2			W	X	1.25	87
4	45.2	32.5	38.9	0.7	0	0	4.2			N		2.00	78
5	45.0	34.4	39.7	1.0	.20	0	8.8			SE		2.25	96
6	40.2	33.2	36.7	1.0	T	0	2.3			E	X	1.38	100
7	39.3	31.9	35.6	1.0	T	0	2.1			NW	X	1.00	94
8	53.2	29.0	41.1	0.7	0	0	3.7			N		1.63	84
9	54.2	40.1	47.2	0.5	0	0	8.2			NNW		2.75	87
10	51.2	41.3	46.3	1.0	T	0	9.8			WNW		3.25	82
11	48.2	33.3	40.8	1.0	T	0	1.6			WNW	X	2.50	91
12	47.2	38.2	42.7	1.0	.22	0	1.6			ESE	X	1.25	97
13	44.3	33.5	38.9	0.9	.09	0	4.7			NW	X	2.00	-
14	47.9	33.6	40.8	1.0	T	0	3.7			W		3.75	92
15	42.0	33.2	37.6	1.0	T	0	4.0			W	X	1.75	95
16	44.9	33.1	39.0	1.0	.19	0	2.6			WSW	X	1.88	100
17	46.6	34.6	40.6	1.0	.55	0	3.1			W	X	1.75	100
18	44.5	33.7	39.1	1.0	.78	0	3.5			W	X	1.75	99
19	47.1	32.0	39.6	1.0	T	0	2.1			W	X	1.00	87
20	45.6	33.0	39.3	1.0	.44	0	2.1			W	X	1.13	98
21	44.1	33.0	38.6	0.8	.16	0	4.0			W		1.00	86
22	43.7	35.1	39.4	0.8	T	0	30.8			W		1.25	84
23	47.1	34.6	40.9	1.0	.59	0	5.8			W	X	2.50	94
24	42.3	34.7	38.5	1.0	.89	0	4.1			W	X	1.75	96
25	44.0	33.9	39.0	1.0	.40	0	4.1			W	X	1.25	92
26	42.3	33.8	38.1	1.0	.51	0	4.1			W	X	1.88	94
27	49.9	32.8	41.4	1.0	.40	0	2.1			NW	X	0.13	85
28	42.2	32.8	37.0	1.0	T	0	4.0			E	X	1.19	96
29	42.0	34.8	38.4	1.0	1.37	0	3.1			E	X	0.88	97
30	46.5	33.0	39.8	1.0	.19	0	4.1			SE	X	1.25	95
31	39.8	31.4	35.6	0.9	T	0	3.0			W		-	92
SUM	1315.5 (a)	984.5 (a)	-	27.1 (a)	8.02 (a)		[illegible] (a)			W	21	48.85 (a)	2578 (b)
MEAN	42.9	32.8	37.9	0.9			4.0					1.63	88.9

BY USWB JUNEAU ALASKA

Maximum and Minimum temperatures taken from observed readings at 0700, 1000 1350, 1600, 1900 and 2200 PST.

*Ablation in inches of firn, sp. gr. 0.50

APPENDIX L - 2 JUNEAU ICE FIELD RESEARCH PROJECT

Camp Number 10 B Month August Year 1950 Elevation 3575 feet.

Date	Maximum Temperature	Minimum Temperature	Mean Temperature	Average Cloudiness	Total Precipitation	Total Snowfall	Average Wind Speed	Average Wind Speed Light	Average Wind Speed Day	Average Wind Direction	Days with Fog	Ablation*	Average Relative Humidity
1	46.2	32.8	39.5	1.0	.39	0	2.9			W		1.00	93
2	46.3	32.5	39.9	1.0	.12	0	1.8			NW		1.25	87
3	47.1	33.6	40.4	1.0	0	0	1.1			NW		1.00	87
4	46.8	33.0	39.9	0.9	.12	0	1.8			NW	X	1.88	91
5	43.3	31.8	37.6	1.0	.12	-	5.7			NW		.75	92
6	41.2	32.8	37.0	0.3	.02	0	6.6			NW		1.00	76
7	47.9	33.6	40.8	0.6	0	0	3.4			NW		.75	76
8	51.1	36.6	43.9	0.2	0	0	4.5			NW		1.00	69
9	53.4	36.6	45.0	0.1	0	0	5.0			W		1.50	74
10				0.0	0							1.50	
11	47.6	36.5	42.1	0.6	0	0	7.8			W		1.50	77
12	45.7	35.0	40.4	0.0	0	0	2.3			NW		1.50	84
13				0.0	0								
14	49.8	36.3	43.1	0.1	0	0	8.5			W		1.25	63
15	47.7	33.1	40.4	0.0	0	0	3.7			NW		1.25	69
16	45.3	31.4	38.4	0.0	0	0	3.4			NW		1.50	73
17	43.4	30.3	36.9	0.2	0	0	4.3			NW		1.50	79
18	49.0	35.4	42.2	0.2	0	0	4.9			W		2.00	81
19	47.2	35.0	41.1	0.7	.01	0	6.0			NW		1.63	80
20	46.1	35.4	40.8	0.2	0.3	0	3.6			NW		1.88	84
21	42.2	34.6	38.4	0.0	0	0	3.7			NW		1.25	84
22	42.2	34.6	38.4	0.1	0	0	4.5			NW	X	1.88	89
23	42.3	35.1	38.7	1.0	.13	0	4.4			NNW	X	1.65	92
24	45.3	34.1	39.7	0.9	.26	0	0.4			NW		1.50	85
25	41.7	35.1	38.4	1.0	3.41	0	2.6			SE	X	.81	97
26	40.9	34.0	37.5	1.0	1.87	0	0.8			NW	X	1.19	95
27	37.9	34.2	36.1	1.0	1.61	0	6.3			SE	X	.75	98
28	36.8	32.4	34.6	1.0	2.04	0	4.3			SE	X	.56	99
29	37.0	32.0	34.5	1.0	.81	0.1	0.9			SE	X	.31	100
30	42.0	32.4	37.2	0.9	.26	0	0.8			NW	X	.56	92
31	48.6	32.3	40.5	0.8	0	0	6.6			NE		0.00	77
SUM	1302.0 (b)	[illegible] (b)	-	16.9 (c)	11.17 (b)	0.1 (c)	112.6 (b)			NW	8	35.10	2443 (b)
MEAN	44.9 (b)	33.4 (b)	39.2	0.6 (c)	-	-	3.9			-	-	1.13	84 (b)

BY USWB JUNEAU ALASKA

*Ablation in inches of firn, sp. gr. 0.50

APPENDIX L - 3 JUNEAU ICE FIELD RESEARCH PROJECT

Camp Number 10B Month September Year 1950 Elevation 3575 feet

Date	Maximum Temperature	Minimum Temperature	Mean Temperature	Average Cloudiness	Total Precipitation	Total Snowfall	Average Wind Speed	Average Wind Speed Light	Average Wind Speed Day	Average Wind Direction	Days with Fog	Ablation*	Average Relative Humidity
1	46.2	33.6	40.0	1.0	1.37	0	3.2			SE	X	1.00	99
2	39.8	31.8	35.8	0.9	1.01	0	1.3			SW	X	.50	94
3	42.2	32.5	37.4	1.0	.43	0	0.1			SE		.13	92
4	39.4	32.0	35.7	1.0	.20	2.0	3.0			SE	X	0.0	99
5	37.0	31.5	34.3	1.0	.26	2.[illegible]	3.7			SE	X	0.0	97
6	48.0	26.0	37.0	0.8	.02	0	1.8			NW		.75**	87
7	47.1	28.0	37.6	0.8	.06	0	2.0			NW		1.00**	89
8	40.0	24.8	32.4	0.4	0	0	3.2			NW		1.50**	85
9	41.0	33.9	37.5	1.0	0	0	2.3			W		1.25**	92
10	41.0	34.0	37.5	1.0	.04	0	3.0			NW	X	1.50	98
11	44.1	32.4	38.3	0.7	0	0	2.7			NW		1.25	93
12	44.3	30.0	37.2	0.0	0	0	4.6			NW		-	82
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													
31													
SUM													
MEAN													

BY USWB JUNEAU ALASKA

*Ablation in inches of firn, sp. gr. 0.50

**Ablation in new snow

APPENDIX M - 1 JUNEAU ICE FIELD RESEARCH PROJECT

Camp Number 16 Month July Year 1950 Elevation 4300 - 4600

Date	Maximum Temperature	Minimum Temperature	Mean Temperature	Average Cloudiness	Total Precipitation	Total Snowfall	Average Wind Speed	Average Wind Speed Night	Average Wind Speed Day	Average Wind Direction	Days With Fog	Ablation	Average Relative Humidity
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15	-	-	-	1.0	T	0	5.2	-	-	SE	X	-	100
16	39.6	39.2	39.4	1.0	1.07	0	16.0	-	-	E	X	-	100
17	41.7	40.6	41.2	1.0	1.20	0	14.5	-	-	E	X	-	100
18	41.4	36.0	38.7	1.0	.31	0	5.2	-	-	E	X	-	100
19	38.8	35.0	36.9	1.0	.25	0	9.3	-	-	SW	X	-	100
20	41.9	35.0	38.5	1.0	.50	0	9.2	-	-	SE	X	-	100
21	50.9	37.0	44.0	0.6	0	0	12.5	-	-	NNE		-	85
22	57.2	43.2	50.2	0.7	T	0	11.3	-	-	N		-	81
23	46.8	39.9	43.4	1.0	.84	0	21.0	-	-	SE	X	-	98
24													
25													
26													
27													
28													
29													
30													
31													
SUM													
MEAN													

BY USWB JUNEAU ALASKA

Max. and Min. taken from 3 hourly observations at 0700 to 2200 PST except from minimum thermometer 19th to 23rd.

APPENDIX M - 2 JUNEAU ICE FIELD RESEARCH PROJECT

Camp Number 16 Month August Year 1950 Elevation 4300 - 4600

Date	Maximum Temperature	Minimum Temperature	Mean Temperature	Average Cloudiness	Total Precipitation	Total Snowfall	Average Wind Speed	Average Wind Speed Night	Average Wind Speed Day	Average Wind Direction	Days With Fog	Ablation	Average Relative Humidity
1													
2													
3													
4													
5													
6													
7													
8													
9	55.9	39.3	52.6	0.3	0	0	20.0	-	-	NE			82
10	67.8	41.8	54.8	0.6	0	0	2.0	-	-	NNW			86
11	67.1	47.3	57.2	0.6	0	0	8.0	-	-	N		1.88	63
12	61.2	43.2	52.2	0.9	T	0	1.7			SW	X	2.00	86
13	59.8	38.3	46.1	1.0	T	0	4.8			NE	X	2.25	87
14	47.0	40.2	43.6	0.4	T	0	23.3			N		3.00	63
15	46.4	33.8	35.1	0	0	0	7.7			N		2.00	58
16	52.4	35.9	44.2	0.1	0	0	5.5			S		1.00	47
17												2.50	
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													
31													
SUM													
MEAN													

BY USWB JUNEAU ALASKA

WB FORM 1080

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

APPENDIX N - 1 (A)

MONTHLY CLIMATOLOGICAL SUMMARY

With Comparative Data

STATION ....Juneau, Alaska (Airport).............. MONTH ......May.......... 19.50..

Phone ...011.... ; 120 ..th Meridian Time; Lat. 58 ° 22 'N, Long 134 ° 35 'W; Elevation ..24.00.. ft.

DATE	Temperature °F: Maximum	Minimum	Mean	Departure from normal	Degree days base 65°	Precipitation: Total (inches)	Snowfall (inches) (unmelted)	Depth of snow on the ground	Wind: Prevailing direction	Highest velocity	Direction	Weather: Percent of possible sunshine	Average cloudiness scale 0 to 10
1	54	34	44	0	[illegible]	0.00	0.0	0	W	13	E	16	10
2	64	51	[illegible]	+4	17	0.00	0.0	0	SW	9	SW	65	8
3	51	40	46	+2	19	0.13	0.0	0	SE	23	SE	0	10
4	46	40	43	-2	22	0.19	0.0	0	SE	26	SE	3	10
5	52	40	46	+2	19	T	0.0	0	ESE	21	SE	35	8
6	51	32	42	-3	23	T	0.0	0	W	12	W	11	9
7	44	39	42	-3	23	0.40	0.0	0	ESE	23	SE	0	10
8	47	42	45	0	20	0.23	0.0	0	E	22	E	0	10
9	52	42	47	+2	18	0.29	0.0	0	ESE	24	SE	12	10
10	48	42	45	-1	20	0.26	0.0	0	E	22	SE	0	10
11	52	42	47	+1	18	0.35	0.0	0	E	34	SE	6	10
12	53	39	46	0	19	0.01	0.0	0	E	13	SE	41	9
13	44	40	42	-5	23	0.07	0.0	0	ESE	23	SE	0	10
14	49	38	44	-3	[illegible]	0.32	0.0	0	E	13	SE	16	10
15	55	31	43	[illegible]	[illegible]	[illegible]	0.0	0	[illegible]	11	[illegible]	100	[illegible]
16	64	29	47	0	[illegible]	0.00	0.0	0	E	[illegible]	SE	61	4
17	51	37	44	-3	21	0.06	0.0	0	SE	17	SE	12	10
18	46	42	44	-3	21	0.43	0.0	0	SE	23	SE	0	10
19	44	39	42	-5	23	0.13	0.0	0	ESE	15	SE	0	10
20	48	37	43	-4	22	0.16	0.0	0	E	16	NE	10	10
21	51	36	44	-3	21	T	0.0	0	[illegible]	15	SW	53	8
22	5[illegible]	37	45	-2	20	T	0.0	0	W	14	SW	38	8
23	52	36	44	[illegible]	21	T	0.0	0	SE	17	SE	5	9
24	48	42	45	-4	20	0.15	0.0	0	SE	29	SE	0	10
25	47	42	45	-3	20	0.39	0.0	0	ESE	17	SE	0	10
26	50	39	45	-4	20	0.34	0.0	0	SE	19	SE	1	10
27	47	40	44	[illegible]	21	0.22	0.0	0	ESE	19	SE	5	10
28	59	40	50	[illegible]	15	0.16	0.0	0	E	12	E	58	9
29	64	35	50	[illegible]	15	0.30	0.0	0	W	17	SW	47	9
30	52	42	47	-3	18	T	0.0	0	W	14	W	3	10
31	60	32	46	-4	19	0.03	0.0	0	W	13	W	100	1
MEAN	51.5	38.0	44.8	-2.0	620	3.34	0.0		[illegible]	34	SE	23	8.8
Normal	-	-	46.8		564	2.95	-						

PRESSURE	Mean		Highest		Date	Lowest		Date
Station	29.945 in.	1014.0 mb	30.402 in.	1032.5 mb	30th	29.415 in.	996.1 mb	4th
Sea Level	29.972 in.	1014.9 mb	30.440 in.	[illegible] mb	30th	29.443 in.	997.2 mb	4th

TEMPERATURE—Mean this month last year 45.8. This month since 1944, warmest 50.2 in 1946; coldest 44.8 in 1950. Highest 64, date 2; lowest 29, date 16. This month since 1944 highest 70, date 1947; lowest 26, date 1949. Average daily departure since Jan. 1 -3.1. Degree days since July 1 2384; normal 1951; since Sept. 1 8652; normal 7951. Number of days:—Max. 100° or above 0; 90° or above 0; —Min. 32° or below 6; 0° or below 0; —10° or below 0. Normal number:—Max. 100° or above 0; 90° or above 0; —Min. 32° or below 6; 0° or below 0; —10° or below 0.

PRECIPITATION—Departure +0.43. Total since Jan. 1 9.32; Dep. -7.42; total since July 1 40.79; Dep. -5.43. Total this month last year 3.59. This month since 1944; wettest 4.37 in 1948; driest 1.25 in 1946.
Greatest this month in: 5 min. .06 date 9; 10 min. .08 date 9; 15 min. .11 date 9; 20 min. .11 date 9; 30 min. .12 date 9; 1 hr. .15 date 9, 28; 2 hr. .25 date 25; 24 hr. .45 date 24, 25.
Greatest this month since 1944, in: 5 min. .06 date 9, 1950; 10 min. .08 date 9, 1950; 15 min. .11 date 9, 1950; 20 min. .11 date 9, 1950; 30 min. .12 date 9, 1950; 1 hr. .15 date 28, 1950; 2 hr. .29 date 19, 1948; 24 hr. 1.39 date 20, 21, 1948.
SNOWFALL—Total since July 1, 92.7; Dep. —. Greatest monthly, this month since 1944, 0.7 in 1945; least monthly this month since 1944, 0 in —. Greatest in 24 hrs. NONE, date —; this month since 1944, 0.7, date 3, 1945. Greatest any single storm NONE, date —; this month since 1944, 0.7, date 3, 1945. Greatest on ground NONE, date —; this month since 1944, T, date 2, 3, 1948.
Number of days with precipitation: trace 6; 0.01 inch or more 19; 0.25 inch or more 5; 1 inch or more 0; 2 inches or more 0.
Normal number of days with precipitation: trace 5; 0.01 inch or more 15; 0.25 inch or more 4; 1 inch or more 0; 2 inches or more 0.
Greatest number of days this month since 1944 with precipitation 0.01 inch or more 21 in 1948; least number 7 in 1945.

CHARACTER OF DAY—Number of days clear 2; partly cloudy 1; cloudy 28. Normal number clear 5; partly cloudy 4; cloudy 22.
SUNSHINE—Total hours this month 110.3. Total hours possible on 1st 15.7; on 16th 16.9; on last day 17.8; this month 501.6.
MISCELLANEOUS PHENOMENA (DATES)—Hail None; Sleet None; Glaze None.
Fog Light (5/16 - 6 mi.) 5/16 to 6 miles 4, 5, 26; Heavy None.
Frost Light 15, 16, 31; Heavy None; Killing None.
Thunderstorms None; Duststorms None; Tornadoes None; Hurricanes None.

City Office. Airport. Total. Monthly. Sunrise to sunset: 0 to 3, clear; 4 to 7, partly cloudy; 8 to 10, cloudy. Other dates. Light fog: visibility 6 miles to 1,000 ft.; heavy, 1,000 ft. to 0. T indicates a trace of precipitation.

Claude V. Brown
Official in Charge, Weather Bureau.

WB FORM 1080

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

APPENDIX N - 2 (A)

MONTHLY CLIMATOLOGICAL SUMMARY

With Comparative Data

STATION ....Juneau, Alaska (Airport).............. MONTH ......June.......... 19.50.

Phone ...011.... ; 120 ..th Meridian Time; Lat. 58 ° 22 'N, Long 134 ° 35 'W; Elevation ..24.00.. ft.

DATE	Temperature °F: Maximum	Minimum	Mean	Departure from normal	Degree days base 65°	Precipitation: Total (inches)	Snowfall (inches) (unmelted)	Depth of snow on the ground	Wind: Prevailing direction	Highest velocity	Direction	Weather: Percent of possible sunshine	Average cloudiness scale 0 to 10
1	63	33	48	-5	17	0.00	0.0	0	W	10	W	63	3
2	52	46	49	-2	16	0.31	0.0	0	ESE	18	SE	0	10
3	60	41	51	0	14	0.02	0.0	0	W	[illegible]	SW	48	8
4	67	34	51	0	14	0.00	0.0	0	W	18	[illegible]	79	4
5	72	44	58	+6	7	0.00	0.0	0	E	16	E	81	3
6	75	40	58	+6	7	0.00	0.0	0	W	14	E	100	0
7	70	42	60	+7	5	0.00	0.0	0	SW	10	SW	100	0
8	74	41	58	+5	7	0.00	0.0	0	W	11	W	100	1
9	61	41	51	-2	14	0.00	0.0	0	[illegible]	17	SE	18	9
10	58	44	51	-2	14	0.00	0.0	0	E	[illegible]	E	14	10
11	65	40	52	-1	13	0.00	0.0	0	[illegible]	14	E	[illegible]	4
12	64	41	53	0	12	0.00	0.0	0	N	14	W	69	6
13	66	47	57	+4	8	0.00	0.0	0	W	14	W	51	6
14	71	42	57	+4	8	0.00	0.0	0	W	13	W	40	5
15	78	44	61	+8	4	0.00	0.0	0	E	10	[illegible]	15	7
16	74	54	64	+11	1	0.00	0.0	0	SW	16	SW	62	[illegible]
17	83	49	66	+13	0	0.00	0.0	0	N	11	SW	100	0
18	81	50	66	+13	0	0.00	0.0	0	[illegible]	8	N	58	5
19	77	57	67	+15	0	0.01	0.0	0	E	[illegible]	E	52	6
20	57	50	54	0	11	0.15	0.0	0	ESE	15	[illegible]	17	9
21	60	49	55	+1	10	T	0.0	0	[illegible]	17	SE	[illegible]	10
22	70	40	55	+1	10	0.00	0.0	0	W	[illegible]	SW	100	[illegible]
23	72	48	60	+5	5	[illegible]	0.0	0	N	[illegible]	W	75	3
24	64	43	54	0	11	0.00	0.0	0	SE	[illegible]	SE	10	[illegible]
25	57	50	54	0	11	0.01	0.0	0	ESE	17	SE	0	10
26	71	45	58	+4	7	0.00	0.0	0	N	[illegible]	W	65	6
27	61	45	53	-1	12	0.42	0.0	0	N	17	E	36	8
28	64	44	54	+1	11	0.07	0.0	0	SW	8	E	7	10
29	68	51	60	+7	5	0.07	0.0	0	ESE	[illegible]	SE	38	9
30	66	47	57	+4	8	T	0.0	0	E	18	SE	21	9
31													
MEAN	67.6	44.7	56.1	+3.4	262	1.00	0.0		E	[illegible]	[illegible]	51	6.2
Normal	-	-	53.0		361	[illegible]	-		-	-	-	-	-

PRESSURE	Mean		Highest		Date	Lowest		Date
Station	29.991 in.	1015.6 mb	30.329 in.	1027.0 mb	1	[illegible] in.	1003.0 mb	22
Sea Level	30.012 in.	1016.2 mb	30.355 in.	1027.9 mb	1	29.670 in.	1004.7 mb	22

TEMPERATURE—Mean this month last year 52.3. This month since 1944, warmest 56.8 in 1946; coldest 52.3 in 1949. Highest 83, date 17; lowest 33, date 1. This month since 1944 highest 83, date 17, 1950; lowest 33, date 1, 1950. Average daily departure since Jan. 1 -2.8. Degree days since July 1 9244; normal 8805; since Sept. 1 8014; normal 8512. Number of days:—Max. 100° or above 0; 90° or above 0; —Min. 32° or below 0; 0° or below 0; —10° or below 0. Normal number:—Max. 100° or above 0; 90° or above 0; —Min. 32° or below 0; 0° or below 0; —10° or below 0.

PRECIPITATION—Departure -2.98. Total since Jan. 1 11.32; Dep. -10.00; total since July 1 46.36; Dep. -8.01. Total this month last year 2.34. This month since 1944; wettest 5.34 in 1949; driest 1.09 in 1951.
Greatest this month in: 5 min. .01 date 27; 10 min. .05 date 27; 15 min. .08 date 20; 30 min. .10 date 20; 30 min. .11 date 20; 1 hr. .16 date 27; 2 hr. .29 date 27; 24 hr. .42 date 27.
Greatest this month since 1944, in: 5 min. .07 date 10, 1945; 10 min. .11 date 9, 1945; 15 min. .11 date 9, 1944; 30 min. .13 date 24, 1944; 30 min. .16 date 24, 1944; 1 hr. .25 date 27, 1948; 2 hr. .34 date 26, 1947; 24 hr. 1.11 date 28-29, 1947.
SNOWFALL—Total since July 1, 92.7; Dep. —. Greatest monthly, this month since 1944, 0 in —; least monthly this month since 1944, 0 in —. Greatest in 24 hrs. 0.0, date —; this month since 1944, 0, date —. Greatest any single storm 0.0, date —; this month since 1944, 0.0, date —. Greatest on ground 0.0, date —; this month since 1944, 0.0, date —.
Number of days with precipitation: trace 2; 0.01 inch or more 8; 0.25 inch or more 2; 1 inch or more 0; 2 inches or more 0.
Normal number of days with precipitation: trace 3; 0.01 inch or more 16; 0.25 inch or more 4; 1 inch or more 0; 2 inches or more 0.
Greatest number of days this month since 1944 with precipitation 0.01 inch or more 25 in 1949; least number 10 in 1946.

CHARACTER OF DAY—Number of days clear 6; partly cloudy 10; cloudy 14. Normal number clear 5; partly cloudy 2; cloudy 22.
SUNSHINE—Total hours this month 31[illegible]. Total hours possible on 1st 17.8; on 16th 18.3; on last day 10.2; this month 5[illegible].
MISCELLANEOUS PHENOMENA (DATES)—Hail None; Sleet None; Glaze None.
Fog Light (5/16 - 6 mi.) None; Heavy (0-1/4 mi.) None.
Frost Light None; Killing None.
Thunderstorms None; Duststorms None; Tornadoes None; Hurricanes None.

City Office. Airport. Total. Monthly. Sunrise to sunset: 0 to 3, clear; 4 to 7, partly cloudy; 8 to 10, cloudy. Other dates. Light fog: visibility 6 miles to 1,000 ft.; heavy, 1,000 ft. to 0. T indicates a trace of precipitation.

Claude V. Brown
Official in Charge, Weather Bureau.

WB FORM 1080

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

APPENDIX N - 3 (A)

MONTHLY CLIMATOLOGICAL SUMMARY

With Comparative Data

STATION ....Juneau, Alaska (Airport).............. MONTH ......July.......... 19.50.

Phone ...011.... ; 120 ..th Meridian Time; Lat. 58 ° 22 'N, Long 134 ° 35 'W; Elevation ..24.00.. ft.

DATE	Temperature °F: Maximum	Minimum	Mean	Departure from normal	Degree days base 65°	Precipitation: Total (inches)	Snowfall (inches) (unmelted)	Depth of snow on the ground	Wind: Prevailing direction	Highest velocity	Direction	Weather: Percent of possible sunshine	Average cloudiness scale 0 to 10
1	66	41	54	0	11	0.00	0.0	0	NNE	12	S	60	6
2	68	40	54	0	11	0.15	0.0	0	W	17	SE	42	8
3	65	46	56	+2	9	0.01	0.0	0	N	10	SW	32	7
4	75	41	58	+4	7	0.00	0.0	0	N	10	SW	50	7
5	62	51	57	+3	8	0.09	0.0	0	E	[illegible]	[illegible]	0	10
6	53	46	50	-4	15	0.08	0.0	0	E	19	N	0	10
7	59	41	50	-4	15	0.04	0.0	0	N	20	E	15	8
8	74	36	55	0	10	0.00	0.0	0	N	15	SE	71	3
9	79	43	61	+6	4	T	0.0	0	[illegible]	17	SE	71	3
10	79	48	64	+9	1	T	0.0	0	E	[illegible]	E	[illegible]	1
11	65	54	60	+5	5	T	0.0	0	SE	18	SE	6	10
12	58	50	54	-1	11	0.03	0.0	0	ESE	17	SE	0	10
13	60	49	55	-1	10	0.21	0.0	0	E	13	[illegible]	4	10
14	64	47	56	0	9	T	0.0	0	[illegible]	7	[illegible]	4	10
15	60	48	54	-2	11	0.02	0.0	0	E	11	E	0	10
16	56	48	52	-4	13	0.86	0.0	0	ESE	19	SE	0	10
17	56	50	53	-3	12	0.74	0.0	0	E	20	SE	0	10
18	55	48	52	-4	13	1.61	0.0	0	E	17	SE	0	10
19	55	47	51	-5	14	0.09	0.0	0	E	17	SE	0	10
20	54	50	52	-4	13	0.23	0.0	0	E	[illegible]	E	0	10
21	68	48	58	+2	7	0.01	0.0	0	[illegible]	[illegible]	[illegible]	51	7
22	74	45	60	+4	5	T	0.0	0	ESE	13	E	[illegible]	7
23	6[illegible]	55	59	+3	6	0.53	0.0	0	E	17	E	0	10
24	57	51	54	-2	11	0.19	0.0	0	E	15	E	0	10
25	60	50	55	-1	10	0.22	0.0	0	E	17	SE	2	10
26	56	47	52	-5	14	0.87	0.0	0	E	11	E	0	10
27	54	45	50	-7	15	0.65	0.0	0	W	7	NE	1	10
28	55	45	50	-7	15	0.07	0.0	0	E	20	SE	0	10
29	59	50	55	-1	10	0.26	0.0	0	ESE	22	SE	2	10
30	54	47	51	-5	14	0.15	0.0	0	E	15	E	1	10
31	57	45	51	-5	14	0.0[illegible]	0.0	0	[illegible]	8	SE	5	10
MEAN	61.9	46.8	54.4	-1.1	322	7.07	0.0		E	22	SE	15	8.7
Normal	-	-	55.5		205	4.22	-		-	-	-	-	-

PRESSURE	Mean		Highest		Date	Lowest		Date
Station	29.985 in.	1015.4 mb	30.270 in.	1025.2 mb	1	[illegible] in.	1002.0 mb	13
Sea Level	30.013 in.	1016.3 mb	30.276 in.	1025.2 mb	1	29.617 in.	1002.0 mb	13

TEMPERATURE—Mean this month last year 53.4. This month since 1943 warmest 56.9 in 1949; coldest 52.7 in 1945. Highest 79, date 10; lowest 36, date 8. This month since 1943 highest 82, date 15, 1947; lowest 36, date 5, 1947. Average daily departure since Jan. 1 -1.1. Degree days since July 1 322; normal 205; since Sept. 1 [illegible]; normal [illegible]. Number of days:—Max. 100° or above 0; 90° or above 5; —Min. 32° or below 0; 0° or below 0; —10° or below [illegible]. Normal number:—Max. 100° or above 0; 90° or above 0; —Min. 32° or below 0; 0° or below 0; —10° or below [illegible].

PRECIPITATION—Departure +2.85. Total since Jan. 1 18.22; Dep. -7.14; total since July 1 7.07; Dep. +2.85. Total this month last year 5.27. This month since 1943; wettest 7.76 in 1945; driest 1.[illegible] in [illegible].
Greatest this month in: 5 min. .03 date 18; 10 min. .06 date 18; 15 min. .08 date 18; 20 min. .12 date 18; 30 min. .12 date 18; 1 hr. .19 date 18; 2 hr. .31 date 16; 24 hr. 1.66 date 17, 18.
Greatest this month since 1943, in: 5 min. .13 date 26, 1945; 10 min. .18 date 26, 1945; 15 min. .25 date 26, 1945; 20 min. .29 date 26, 1945; 30 min. .32 date 26, 1945; 1 hr. .47 date 27, 1948; 2 hr. .54 date 26, 1945; 24 hr. 1.67 date 6-7, 1945.
SNOWFALL—Total since July 1, 0.0; Dep. [illegible]. Greatest monthly, this month since 1943, 0 in [illegible]; least monthly this month since 1943, 0 in [illegible]. Greatest in 24 hrs. 0.0, date —; this month since 1943, 0, date —. Greatest any single storm 0.0, date —; this month since 1943, 0, date —. Greatest on ground 0.0, date —; this month since 1943, 0, date —.
Number of days with precipitation: trace 5; 0.01 inch or more 23; 0.25 inch or more 7; 1 inch or more 1; 2 inches or more [illegible].
Normal number of days with precipitation: trace 6; 0.01 inch or more 20; 0.25 inch or more 7; 1 inch or more 1; 2 inches or more [illegible].
Greatest number of days this month since 1943 with precipitation 0.01 inch or more 23 in 1945; least number 14 in [illegible].

CHARACTER OF DAY—Number of days clear 2; partly cloudy 6; cloudy 23. Normal number clear 1; partly cloudy 5; cloudy —.
SUNSHINE—Total hours this month 101.9. Total hours possible on 1st 18.2; on 16th 17.6; on last day 16.6; this month [illegible].
MISCELLANEOUS PHENOMENA (DATES)—Hail None; Sleet None; Glaze None.
Fog Light (5/16 - 6 mi.) 16, 17, 24, 25; Heavy (0-1/8 mi.) None.
Frost Light None (Aurora Borealis - None); Killing None.
Thunderstorms None; Duststorms None; Tornadoes None; Hurricanes None.

City Office. Airport. Total. Monthly. Sunrise to sunset: 0 to 3, clear; 4 to 7, partly cloudy; 8 to 10, cloudy. Other dates. Light fog: visibility 6 miles to 1,000 ft.; heavy, 1,000 ft. to 0. T indicates a trace of precipitation.

Claude V. Brown
Official in Charge, Weather Bureau.

APPENDIX N - 1 (B)

STATION........Juneau, Alaska (Airport).............MONTH.....May..........19.50

PSYCHROMETRIC DATA taken at....twenty minutes past the hour

Date	0430 PST Dry	0430 PST Wet	0430 PST Dew Pt.	0430 PST Rel. Hum.	1030 PST Dry	1030 PST Wet	1030 PST Dew Pt.	1030 PST Rel. Hum.	1630 PST Dry	1630 PST Wet	1630 PST Dew Pt.	1630 PST Rel. Hum.	2230 PST Dry	2230 PST Wet	2230 PST Dew Pt.	2230 PST Rel. Hum.
1	35	35	[illegible]	[illegible]	45	[illegible]	[illegible]	58	54	45	32	47	44	42	[illegible]	[illegible]
2	52	52	41	95	52	46	39	62	61	51	37	37	45	42	[illegible]	[illegible]
3	41	39	37	85	45	45	[illegible]	72	[illegible]	44	37	61	43	42	[illegible]	[illegible]
4	45	41	39	84	46	43	[illegible]	51	[illegible]	41	36	71	41	39	[illegible]	[illegible]
5	[illegible]	39	37	[illegible]	49	[illegible]	[illegible]	75	[illegible]	44	37	60	[illegible]	42	[illegible]	[illegible]
6	44	33	[illegible]	[illegible]	46	42	[illegible]	58	[illegible]	43	34	52	42	40	37	[illegible]
7	45	50	[illegible]	[illegible]	43	42	[illegible]	[illegible]	[illegible]	48	41	92	43	42	[illegible]	[illegible]
8	[illegible]	45	[illegible]	[illegible]	[illegible]	43	[illegible]	92	47	46	45	95	47	46	[illegible]	[illegible]
9	[illegible]	46	[illegible]	[illegible]	52	[illegible]	45	84	[illegible]	45	44	[illegible]	43	41	[illegible]	[illegible]
10	[illegible]	41	[illegible]	91	[illegible]	[illegible]	[illegible]	61	[illegible]	[illegible]	42	[illegible]	[illegible]	45	[illegible]	[illegible]
11	[illegible]	46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63	[illegible]	43	42	[illegible]	[illegible]	42	[illegible]	[illegible]
12	[illegible]	39	36	[illegible]	[illegible]	[illegible]	37	71	[illegible]	45	36	53	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	36	[illegible]	[illegible]	[illegible]	[illegible]	61	[illegible]	[illegible]	39	84	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	36	65	[illegible]	41	39	54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	52	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	39	[illegible]	43	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	37	87
20	[illegible]	37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	[illegible]	[illegible]	[illegible]	[illegible]
21	38	37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	54	[illegible]	43	[illegible]	[illegible]	[illegible]	[illegible]	33	73
22	39	37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	35	76
23	[illegible]	38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	46	41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	91	45	43	[illegible]	87	[illegible]	43	[illegible]	84
25	43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	95	46	[illegible]	[illegible]	[illegible]	[illegible]	43	[illegible]	[illegible]
26	39	[illegible]	[illegible]	[illegible]	47	[illegible]	41	79	46	[illegible]	[illegible]	[illegible]	43	41	39	95
27	[illegible]	40	42	[illegible]	[illegible]	[illegible]	[illegible]	86	45	43	41	[illegible]	42	40	37	88
28	[illegible]	39	37	97	49	[illegible]	[illegible]	71	57	45	[illegible]	[illegible]	46	43	40	78
29	[illegible]	37	35	91	56	45	32	[illegible]	63	48	[illegible]	[illegible]	[illegible]	43	35	[illegible]
30	[illegible]	40	35	72	48	42	35	50	51	43	[illegible]	[illegible]	45	42	37	[illegible]
31	[illegible]	33	32	95	35	35	[illegible]	70	59	47	[illegible]	[illegible]	[illegible]	[illegible]	35	[illegible]
MEAN	[illegible]	38.4	36.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Normal																

WIND — Number of hours this month below 10 mi.........; 10 mi. and over......; 15 mi. and over......; 20 mi. and over........
25 mi. and over........; 30 mi. and over......; 40 mi. and over........

This Month — Dir.	N	NE	E	SE	S	SW	W	NW	DI	Month
Aver. Hrly. Vel.										
Percent of Time										

Maximum velocity this month since.............miles from........on........in........

CEILING AND VISIBILITY FREQUENCIES (Based on hourly record observations) at........

Visibility (miles)	Ceiling (feet) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	Over 9500	Total
0 to 3/16										
5/16 to 5/8										
3/4 to 7/8										
1 to 2 1/2		1								1
3 to 6						14	6	1		21
7 to 15					2	79	213	25	1	320
20 to 30						5	128	113	156	402
35 or more										
Total		1			2	98	347	139	157	744

Frequencies for larger classes can be derived by addition, i.e., "Under 500 feet" from sum of 0, 100-200 and 300-400 classes; "7 miles or more" from sum of classes 7 to 35 miles or more inclusive.

FREEZE — Average date of last killing freeze (or frost) in spring....May 1..........; first in autumn..October 2......
Latest date of last killing freeze (or frost) in spring....May 12, 1944......; earliest in autumn..August 25, 1948
Average growing season....152......days; longest..173.........days in..1946..; shortest..108.....days in..1948

GENERAL SUMMARY —

The temperature for May continued below normal. This was the seventh consecutive month with below normal temperature.
The total May precipitation was slightly above normal while there was less sunshine and more cloudy days. This was the first month since October, 1949 that the precipitation was above normal.

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STATION........Juneau, Alaska (Airport)..............MONTH.......June.........19.50.

APPENDIX N - 2 (B)

PSYCHROMETRIC DATA taken at......twenty minutes past the hour

Date	0430 PST Dry	0430 PST Wet	0430 PST Dew Pt.	0430 PST Rel. Hum.	1030 PST Dry	1030 PST Wet	1030 PST Dew Pt.	1030 PST Rel. Hum.	1630 PST Dry	1630 PST Wet	1630 PST Dew Pt.	1630 PST Rel. Hum.	2230 PST Dry	2230 PST Wet	2230 PST Dew Pt.	2230 PST Rel. Hum.
1	54	53	52	90	57	48	38	48	63	50	37	38	53	46	39	58
2	47	45	44	88	47	46	45	91	50	48	46	87	48	47	46	93
3	45	44	43	91	50	46	42	73	57	48	39	50	46	42	38	73
4	35	34	33	92	55	48	40	57	66	52	39	37	50	46	42	74
5	45	43	40	82	57	50	43	60	70	56	44	39	55	50	44	66
6	41	40	39	92	59	53	47	65	73	57	44	36	54	47	39	56
7	42	41	40	91	63	55	49	58	78	59	43	29	55	48	40	56
8	42	41	39	89	64	53	44	49	74	56	40	30	53	46	39	58
9	42	40	38	84	53	53	46	68	57	52	48	71	52	48	44	76
10	45	43	41	86	56	50	45	62	56	49	42	59	43	45	41	76
11	41	40	39	90	58	51	45	61	62	53	45	54	52	47	42	68
12	42	41	40	92	59	53	48	74	64	55	49	57	55	49	46	76
13	50	47	44	81	57	50	44	61	65	54	45	49	51	46	41	68
14	43	42	39	87	52	52	46	63	69	57	48	47	54	48	42	64
15	44	43	41	89	53	56	50	63	72	61	50	39	61	53	46	58
16	57	51	46	69	66	57	50	57	71	62	56	60	59	53	48	67
17	49	47	45	85	66	59	54	65	83	67	57	42	64	54	46	53
18	50	50	49	95	69	60	54	59	81	66	50	47	63	56	51	64
19	65	58	53	65	72	62	57	59	73	62	55	54	60	58	57	90
20	57	54	52	83	54	51	48	79	56	50	44	64	52	47	45	71
21	50	46	42	71	54	48	42	62	58	50	42	54	50	46	41	70
22	41	40	38	91	57	51	46	65	68	56	47	46	55	50	46	73
23	49	46	43	80	61	54	49	64	72	60	51	48	56	52	49	77
24	44	43	42	91	57	53	50	77	62	55	50	64	56	51	47	72
25	52	50	48	89	54	50	47	78	56	52	49	77	54	[illegible]	48	80
26	45	44	42	89	60	55	51	72	71	59	51	49	54	49	43	66
27	49	46	42	76	51	50	49	93	54	53	52	92	49	47	46	87
28	48	47	46	93	59	54	50	72	64	59	55	73	55	53	52	87
29	53	52	52	96	64	58	54	70	67	58	52	59	54	51	49	85
30	53	51	49	85	56	52	48	72	60	54	50	60	52	48	45	72
31	46.7	44.7	42.7	86	58.7	52.6	47.5	67	66.9	55.7	47.6	54	54.2	50.1	46.6	71
MEAN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Normal																

WIND — Number of hours this month below 10 mi........; 10 mi. and over......; 15 mi. and over......; 20 mi. and over........
25 mi. and over........; 30 mi. and over......; 40 mi. and over........

This Month — Dir.	N	NE	E	SE	S	SW	W	NW	DI	Month
Aver. Hrly. Vel.										
Percent of Time										

Maximum velocity this month since........ ......miles from........on........in........

CEILING AND VISIBILITY FREQUENCIES (Based on hourly record observations) at........

Visibility (miles)	Ceiling (feet) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	Over 9500	Total
0 to 3/16										
5/16 to 5/8										
3/4 to 7/8										
1 to 2 1/2										
3 to 6						1				1
7 to 15						6	38	12	21	77
20 to 30						6	82	148	106	642
35 or more										
Total						13	120	160	427	720

Frequencies for larger classes can be derived by addition, i.e., "Under 500 feet" from sum of 0, 100-200 and 300-400 classes; "7 miles or more" from sum of classes 7 to 35 miles or more inclusive.

FROST DATA — Average date of last freeze (or frost) in spring......May 1..........; first in autumn..........Oct. 2
Latest date of last freeze (or frost) in spring......May 10, 1944..........; earliest in autumn..August 25.....1948
Average growing season....152........days; longest....173..........days in..1946..; shortest..108.....days in..1948

GENERAL SUMMARY — The month of June was sunny, warm and dry. The amount of sunshine was the highest ever recorded in June since the airport Station was established in July 1943.

The mean June temperature reached within .4 of a degree of that in 1946 which is the highest on record. This is the first month since October 1949 that temperatures have been above the normal mean. Both the maximum and minimum temperature readings were equaled this June. The highest temperature of 83 degrees equals that of 1946 and 1948 and the lowest temperature of 33 degrees equals that of 1949.

The total precipitation of 1.08 inches was well below the June normal and equaled the lowest previous record in 1946.

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STATION......Juneau, Alaska (Airport)..............MONTH......July..........1950..

APPENDIX N - 3 (B)

PSYCHROMETRIC DATA taken at....twenty minutes past the hour

Date	0430 PST Dry	0430 PST Wet	0430 PST Dew Pt.	0430 PST Rel. Hum.	1030 PST Dry	1030 PST Wet	1030 PST Dew Pt.	1030 PST Rel. Hum.	1630 PST Dry	1630 PST Wet	1630 PST Dew Pt.	1630 PST Rel. Hum.	2230 PST Dry	2230 PST Wet	2230 PST Dew Pt.	2230 PST Rel. Hum.
1	41	40	39	93	61	54	[illegible]	[illegible]	[illegible]	57	53	73	[illegible]	47	41	[illegible]
2	42	41	40	94	60	54	51	70	[illegible]	57	51	61	52	51	49	[illegible]
3	49	48	46	92	57	53	50	78	64	57	52	64	51	47	42	73
4	41	40	38	91	60	54	49	60	72	60	51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	53	48	44	73	55	54	53	92	55	53	51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	47	46	45	91	51	49	47	87	49	48	47	[illegible]	[illegible]	47	46	[illegible]
7	46	45	44	93	51	48	44	94	57	50	44	62	45	43	40	[illegible]
8	37	36	35	94	56	51	46	70	71	59	50	49	55	[illegible]	41	59
9	44	43	42	90	73	59	49	42	79	63	52	39	62	[illegible]	42	[illegible]
10	49	45	42	75	68	59	52	52	72	58	52	43	[illegible]	41	45	[illegible]
11	56	52	49	75	57	53	50	76	62	[illegible]	52	65	57	[illegible]	48	[illegible]
12	53	51	49	87	54	53	51	[illegible]	57	53	50	76	54	[illegible]	52	[illegible]
13	52	50	48	87	58	54	51	77	[illegible]	51	55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	47	46	46	96	55	52	49	81	60	59	[illegible]	62	[illegible]	[illegible]	[illegible]	[illegible]
15	52	49	47	94	56	53	50	79	59	[illegible]	52	77	51	[illegible]	[illegible]	[illegible]
16	52	51	50	92	54	51	48	[illegible]	55	51	[illegible]	[illegible]	54	[illegible]	51	[illegible]
17	54	53	52	94	55	54	53	[illegible]	54	53	[illegible]	[illegible]	53	[illegible]	51	[illegible]
18	48	48	47	97	52	51	50	94	53	51	50	94	51	[illegible]	49	[illegible]
19	47	47	46	96	54	52	51	[illegible]	53	51	50	90	52	[illegible]	[illegible]	[illegible]
20	52	51	49	90	54	52	50	[illegible]	53	52	51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	49	48	47	93	56	54	53	[illegible]	65	58	[illegible]	[illegible]	54	[illegible]	[illegible]	[illegible]
22	45	44	43	93	65	59	54	[illegible]	[illegible]	60	[illegible]	[illegible]	59	[illegible]	[illegible]	[illegible]
23	55	54	53	93	59	58	57	94	[illegible]	58	56	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	55	55	54	95	56	54	52	86	[illegible]	55	54	[illegible]	[illegible]	[illegible]	51	93
25	49	48	47	95	54	53	52	[illegible]	[illegible]	57	56	[illegible]	57	[illegible]	55	[illegible]
26	54	53	52	94	52	51	51	[illegible]	51	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	47	46	46	95	53	51	50	89	[illegible]	50	47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	46	44	42	89	50	49	48	[illegible]	53	50	47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	51	50	49	93	54	52	51	90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	50	48	47	91	51	[illegible]	47	[illegible]	53	51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	48	47	46	93	53	50	48	83	54	[illegible]	47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MEAN	48.7	[illegible]	[illegible]	91	[illegible]	[illegible]	[illegible]	91	[illegible]	[illegible]	50.8	75	[illegible]	[illegible]	[illegible]	[illegible]
Normal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

WIND — Number of hours this month below 10 mi........: 10 mi. and over......: 15 mi. and over......: 20 mi. and over........
25 mi. and over........: 30 mi. and over......: 40 mi. and over........

This Month — Dir.	N	NE	E	SE	S	SW	W	NW	DI	Month
Aver. Hrly. Vel.										
Percent of Time										

Maximum velocity this month since..............miles from........on........in........

CEILING AND VISIBILITY FREQUENCIES (Based on hourly record observations) at........

Visibility (miles)	Ceiling (feet) 0	100-200	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	Over 9500	Total
0 to 3/16										
5/16 to 5/8										
3/4 to 7/8										
1 to 2 1/2					1	1				2
3 to 6					[illegible]	[illegible]	[illegible]	[illegible]		78
7 to 15					[illegible]	72	175	[illegible]		[illegible]
20 to 30						7	115	17	173	[illegible]
35 or more										
Total					8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Frequencies for larger classes can be derived by addition, i.e., "Under 500 feet" from sum of 0, 100-200 and 300-400 classes; "7 miles or more" from sum of classes 7 to 35 miles or more inclusive.

FREEZE — Average date of last killing freeze (or frost) in spring......May 1..........; first in autumn..October 2
Latest date of last killing freeze (or frost) in spring..May 10, 1944..........; earliest in autumn..August 25, 1948
Average growing season...152.........days; longest...173.........days in..1946....; shortest.....108.........days in..[illegible]

GENERAL SUMMARY — The temperature for July averaged below normal but the first third of the month was above. The lowest temperature reading of 36 degrees on the 8th was the lowest July reading on record at the airport.

The total precipitation of 7.07" was exceeded only in 19[illegible]5 when 7.75 inches of rain was recorded. Rain fell each day except two days the first eight days of the month.

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WB FORM 1030

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

APPENDIX M - 4 (A)

MONTHLY CLIMATOLOGICAL SUMMARY

With Comparative Data

STATION Juneau, Alaska (Airport) MONTH August 1950

Phone 011 : 120 th Meridian Time; Lat. 58 ° 22 'N. Long 134 ° 35 'W: Elevation 24.00 ft.

DATE	TEMPERATURE °F Maximum	Minimum	Mean	Departure from normal	Degree days base 65°	PRECIPITATION Total (inches)	Snowfall (inches) (unmelted)	Depth of snow on the ground	WIND Prevailing direction	Highest velocity	Direction	WEATHER Percent of possible sunshine	Average cloudiness scale 0 to 10
1	53	45	49	-5	16	0.45	0.0	0	N	8	E	0	10
2	56	46	51	-2	14	0.16	0.0	0	E	10	E	2	10
3	58	47	53	0	12	T	0.0	0	N	12	E	0	10
4	53	42	48	-6	17	0.19	0.0	0	E	19	E	0	10
5	65	41	53	-1	12	0.01	0.0	0	N	9	E	41	9
6	70	40	55	+1	10	0.00	0.0	0	N	8	SW	60	4
7	68	46	57	+3	8	0.00	0.0	0	N	10	E	36	8
8	76	42	59	+5	6	0.00	0.0	0	N	17	E	71	3
9	78	41	60	+6	5	0.00	0.0	0	N	15	NE	74	1
10	76	42	59	+6	5	0.00	0.0	0	N	8	N	71	5
11	77	44	61	+6	4	0.00	0.0	0	E	16	E	56	7
12	69	52	61	+6	4	T	0.0	0	E	16	SE	34	9
13	69	51	60	+7	5	T	0.0	0	N	8	N	15	9
14	74	49	62	+9	3	0.03	0.0	0	N	14	NE	78	3
15	72	43	58	+5	7	0.00	0.0	0	E	11	SE	100	0
16	74	37	56	+3	9	0.00	0.0	0	SE	10	S	100	0
17	71	39	55	+2	10	0.00	0.0	0	S	11	S	96	2
18	77	40	59	+6	6	0.00	0.0	0	SW	10	SW	100	2
19	67	43	55	+2	10	T	0.0	0	N	7	N	28	9
20	72	52	64	+11	1	0.00	0.0	0	N	12	N	61	5
21	76	45	61	+8	4	0.00	0.0	0	N	7	N	100	0
22	77	46	62	+9	3	0.00	0.0	0	N	10	SW	97	4
23	66	52	59	+6	6	0.28	0.0	0	N	16	SE	3	10
24	61	53	57	+4	8	0.41	0.0	0	E	17	SE	21	10
25	57	52	55	+3	10	1.73	0.0	0	ESE	22	SE	0	10
26	56	47	52	0	13	1.10	0.0	0	ESE	23	SE	0	10
27	54	49	52	0	13	0.24	0.0	0	ESE	28	SE	0	10
28	53	48	51	0	14	0.22	0.0	0	ESE	28	SE	0	10
29	53	48	51	0	14	0.11	0.0	0	ESE	22	SE	0	10
30	60	46	53	+3	12	0.02	0.0	0	E	15	E	33	8
31	64	41	53	+3	12	T	0.0	0	SW	22	E	46	7
Mean	66.3	45.5	56.2	+4	274	4.95	0.0		N	29	SE	44	6.6
Normal	-	-	52.6		378	4.72	-		-	-	-	-	-

PRESSURE	Mean		Highest		Date	Lowest		Date
Station	29.936 in.	1013.7 mb.	30.288 in.	1025.6 mb.	17	29.472 in.	997.9 mb.	31
Sea Level	29.963 in.	1014.6 mb.	30.314 in.	1026.5 mb.	17	29.[illegible] in.	998.0 mb.	31

TEMPERATURE — Mean this month last year 52.8. This month since 1943, warmest 56.2 in 1950, coldest 52.4 in 19[illegible]. Highest 78 date 9, lowest 37 date 16. This month since 1943 highest 79 date 22, 1942; lowest 27 date 25, 1948. Average daily departure since Jan. 1 +2.5 Degree days since July 1 596, normal 673, since Sept. 1 [illegible], normal 8965. Number of days: — Max. 100° or above 0; 90° or above 0; — Min. 32° or below 0; 0° or below 0; −10° or below 0. Normal number: — Max. 100° or above 0; 90° or above 0; — Min. 32° or below 0; 0° or below 0; −10° or below 0.

PRECIPITATION — Departure +0.23. Total since Jan. 1 22.92. Dep. +6.91. total since July 1 12.02. Dep. +3.00. Total this month last year 3.52. This month since 1943, wettest 9.47 in 1947, driest 1.39 in 1948.

Greatest this month in: 5 min. .25 date 25; 10 min. .28 date 24; 15 min. .10 date 24; 20 min. .12 date 24; 30 min. .17 date 24; 1 hr. .21 date 25; 2 hr. .37 date 25; 24 hr. 1.73 date 25.

Greatest this month since 1943 in: 5 min. .25 date 7, 1945; 10 min. .28 date 7, 1945; 15 min. .10 date 7, 1945; 20 min. .12 date 24, 1950; 30 min. .17 date 24, 1950; 1 hr. .22 date 7, 1945; 2 hr. .37 date 25, 1950; 24 hr. 2.38 date 25-26, 1947.

SNOWFALL — Total since July 1 0. Dep. 0. Greatest monthly, this month since 1943 0 in. Least monthly this month since 1943 0 in. Greatest in 24 hrs. 0 date. this month since 1943 0 date. Greatest any single storm 0 date. this month since 1943 0 date. Greatest on ground 0 date. this month since 1943 0 date.

Number of days with precipitation: trace 5; 0.01 inch or more 13; 0.25 inch or more 5; 1 inch or more 2; 2 inches or more [illegible]. Normal number of days with precipitation: trace 4; 0.01 inch or more 17; 0.25 inch or more 2; 1 inch or more 1; 2 inches or more [illegible]. Greatest number of days this month since 1943 with precipitation 0.01 inch or more 22 in 1943, least number 13 in 1[illegible].

CHARACTER OF DAY — Number of days clear 8; partly cloudy 6; cloudy 17. Normal number clear 4; partly cloudy 6; cloudy 21.
SUNSHINE — Total hours this month 208.6. Total hours possible on 1st 16.5, on 16th 15.3, on last day 14.1, this month 47[illegible].
MISCELLANEOUS PHENOMENA (DATES) — Hail None. Sleet None. Glaze None.
Fog Light (5/16 - 6 mi.) 6, 26, 31. Heavy (0-1/4 mi.) None.
Frost Light Aurora Borealis 7, 8, 9, 18, 19, 20, 21. Killing None.
Thunderstorms None. Duststorms None. Tornadoes None. Hurricanes None.

Claude V. Brown
Official in Charge, Weather Bureau.

WB FORM 1030

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

APPENDIX M - 5 (A)

MONTHLY CLIMATOLOGICAL SUMMARY

With Comparative Data

STATION Juneau, Alaska (Airport) MONTH September 1950

Phone 011 : 120 th Meridian Time; Lat. 58 ° 22 'N. Long 134 ° 35 'W: Elevation [illegible] ft.

DATE	TEMPERATURE °F Maximum	Minimum	Mean	Departure from normal	Degree days base 65°	PRECIPITATION Total (inches)	Snowfall (inches) (unmelted)	Depth of snow on the ground	WIND Prevailing direction	Highest velocity	Direction	WEATHER Percent of possible sunshine	Average cloudiness scale 0 to 10
1	55	49	52	+1	13	0.69	0.0	0	ESE	34	SE	0	10
2	56	46	51	0	14	0.23	0.0	0	ESE	30	SE	4	9
3	57	45	51	0	14	0.27	0.0	0	E	12	E	10	10
4	50	47	49	-2	16	0.67	0.0	0	SE	30	SE	0	10
5	49	46	48	-3	17	0.28	0.0	0	ESE	24	SE	0	10
6	54	42	48	-3	17	0.01	0.0	0	[illegible]	10	E	1	10
7	[illegible]	38	49	-2	16	T	0.0	0	ENE	10	E	17	9
8	61	34	48	-3	17	0.00	0.0	0	SW	9	E	76	[illegible]
9	62	46	54	+3	11	0.07	0.0	0	E	6	W	12	10
10	56	42	51	+1	14	0.20	0.0	0	N	[illegible]	N	2	10
11	62	42	52	+2	13	0.00	0.0	0	N	[illegible]	SW	64	8
12	61	38	[illegible]	0	15	0.00	0.0	0	[illegible]	14	[illegible]	59	3
13	63	37	50	+1	15	0.00	0.0	0	N	10	SW	76	3
14	62	37	[illegible]	+1	15	0.07	0.0	0	E	17	E	65	7
15	57	44	[illegible]	+2	[illegible]	T	0.0	0	E	12	E	0	10
16	61	44	53	+5	12	0.00	0.0	0	N	[illegible]	N	41	8
17	52	46	49	+1	16	0.11	0.0	0	[illegible]	[illegible]	SE	0	10
18	53	45	49	+1	16	0.11	0.0	0	[illegible]	22	SE	0	10
19	57	52	54	+7	11	0.24	0.0	0	ESE	30	SE	11	10
20	[illegible]	46	51	+4	14	1.21	0.0	0	E	[illegible]	SE	2	10
21	54	45	[illegible]	+5	10	1.72	0.0	0	SE	30	SE	0	10
22	56	49	53	+7	12	0.76	0.0	0	ESE	34	SE	8	10
23	53	47	50	+4	15	0.40	0.0	0	SE	[illegible]	SE	0	10
24	51	47	49	+3	16	0.12	0.0	0	ESE	27	SE	0	10
25	50	[illegible]	[illegible]	+1	17	0.07	0.0	0	E	[illegible]	SE	0	10
26	52	42	47	0	18	0.02	0.0	0	[illegible]	9	E	11	9
27	54	42	[illegible]	+1	17	0.06	0.0	0	[illegible]	[illegible]	E	9	9
28	52	36	44	[illegible]	[illegible]	T	0.0	0	[illegible]	9	SW	25	9
29	55	34	45	[illegible]	[illegible]	0.00	0.0	0	[illegible]	[illegible]	SW	100	[illegible]
30	[illegible]	[illegible]	43	-3	[illegible]	0.00	0.0	0	E	8	E	100	[illegible]
31													
Mean	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.24	[illegible]		[illegible]	37	SE	23	8.3
Normal	-	-	[illegible]		[illegible]	[illegible]	[illegible]		-	-	-	-	-

PRESSURE	Mean		Highest		Date	Lowest		Date
Station	[illegible] in.	[illegible] mb.	[illegible] in.	[illegible] mb.	[illegible]	[illegible] in.	[illegible] mb.	[illegible]
Sea Level	[illegible] in.	[illegible] mb.	[illegible] in.	[illegible] mb.	[illegible]	[illegible] in.	[illegible] mb.	[illegible]

TEMPERATURE — Mean this month last year [illegible]. This month since 1943, warmest [illegible], coldest [illegible]. Highest [illegible] date [illegible], lowest [illegible] date [illegible]. This month since 1943 highest [illegible] date [illegible], lowest [illegible] date [illegible]. Average daily departure since Jan. 1 [illegible]. Degree days since July 1 [illegible], normal [illegible], since Sept. 1 [illegible], normal [illegible]. Number of days: — Max. 100° or above 0; 90° or above 0; — Min. 32° or below [illegible]; 0° or below [illegible]; −10° or below [illegible]. Normal number: — Max. 100° or above [illegible]; 90° or above [illegible]; — Min. 32° or below [illegible]; 0° or below [illegible]; −10° or below [illegible].

PRECIPITATION — Departure [illegible]. Total since Jan. 1 [illegible]. Dep. [illegible]. total since July 1 [illegible]. Dep. [illegible]. Total this month last year [illegible]. This month since 1943, wettest [illegible] in [illegible], driest [illegible] in [illegible].

Greatest this month in: 5 min. [illegible]; 10 min. [illegible]; 15 min. [illegible]; 20 min. [illegible]; 30 min. [illegible]; 1 hr. [illegible]; 2 hr. [illegible]; 24 hr. [illegible] date 21-22.

Greatest this month since 1943 in: 5 min. [illegible]; 10 min. [illegible]; 15 min. [illegible]; 20 min. [illegible]; 30 min. [illegible]; 1 hr. [illegible]; 2 hr. [illegible]; 24 hr. [illegible].

SNOWFALL — Total since July 1 [illegible]. Dep. [illegible]. Greatest monthly, this month since [illegible]. Least monthly this month since [illegible]. Greatest in 24 hrs. [illegible]. Greatest any single storm [illegible]. Greatest on ground [illegible].

Number of days with precipitation: trace [illegible]; 0.01 inch or more [illegible]; 0.25 inch or more [illegible]; 1 inch or more [illegible]; 2 inches or more [illegible]. Normal number of days with precipitation: trace [illegible]; 0.01 inch or more [illegible]; 0.25 inch or more [illegible]; 1 inch or more [illegible]; 2 inches or more [illegible]. Greatest number of days this month since [illegible] with precipitation 0.01 inch or more [illegible], least number [illegible].

CHARACTER OF DAY — Number of days clear [illegible]; partly cloudy [illegible]; cloudy [illegible]. Normal number clear [illegible]; partly cloudy [illegible]; cloudy [illegible].
SUNSHINE — Total hours this month [illegible]. Total hours possible on 1st [illegible], on 16th [illegible], on last day [illegible], this month [illegible].
MISCELLANEOUS PHENOMENA (DATES) — Hail [illegible]. Sleet [illegible]. Glaze [illegible].
Fog Light (5/16 - 6 mi.) [illegible]. Heavy (0-1/4 mi.) [illegible].
Frost Light [illegible]. Killing [illegible].
Thunderstorms [illegible]. Aurora Borealis 12, 13, 30. Duststorms [illegible]. Tornadoes [illegible]. Hurricanes [illegible].

Claude V. Brown
Official in Charge, Weather Bureau.

WB FORM 1030

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

APPENDIX M - 6 (A)

MONTHLY CLIMATOLOGICAL SUMMARY

With Comparative Data

STATION Juneau, Alaska MONTH October 1950

Phone 011 : 120 th Meridian Time; Lat. 58 ° 22 'N. Long 134 ° 35 'W: Elevation [illegible] ft.

DATE	TEMPERATURE °F Maximum	Minimum	Mean	Departure from normal	Degree days base 65°	PRECIPITATION Total (inches)	Snowfall (inches) (unmelted)	Depth of snow on the ground	WIND Prevailing direction	MAX Highest velocity	Direction	WEATHER Percent of possible sunshine	Average cloudiness scale 0 to 10
1	53	29	41	-4	24	0.00	0.0	0	SW	8	SW	90	0
2	56	29	43	-2	22	0.00	0.0	0	SW	6	SW	100	0
3	52	27	40	-4	25	0.00	0.0	0	SW	7	SW	59	5
4	50	33	42	-2	23	T	0.0	0	N	7	N	6	9
5	51	31	41	-3	24	T	0.0	0	N	7	NE	6	10
6	56	38	47	+3	18	0.04	0.0	0	N	10	E	25	8
7	56	43	50	+6	15	0.38	0.0	0	SE	27	E	0	10
8	49	43	46	+3	19	0.28	0.0	0	E	18	SE	0	10
9	50	42	46	+3	19	0.03	0.0	0	E	18	SE	0	10
10	49	39	44	+1	21	0.29	0.0	0	SE	18	SE	0	10
11	48	44	46	+3	19	0.22	0.0	0	SE	27	SE	0	10
12	46	43	45	+2	20	0.12	0.0	0	ESE	20	SE	0	10
13	49	41	45	+3	20	0.02	0.0	0	ESE	17	SE	0	10
14	48	37	43	+1	22	0.01	0.0	0	N	11	N	30	6
15	44	38	41	-1	24	0.24	0.0	0	E	11	E	0	10
16	47	20	38	-3	27	0.00	0.0	0	N	8	SW	100	0
17	50	24	37	-4	28	0.00	0.0	0	W	7	N	100	1
18	48	23	36	-5	29	0.00	0.0	0	SW	6	SW	61	3
19	43	22	33	-7	32	T	0.0	0	N	10	E	58	6
20	41	36	39	-1	26	0.29	0.0	0	E	20	SE	0	10
21	42	35	39	-1	26	0.85	0.0	0	ESE	24	SE	0	10
22	43	25	34	-6	31	0.05	0.0	0	N	6	SE	75	2
23	39	24	32	-8	33	0.36	T	0	SE	21	SE	0	10
24	43	30	37	-2	28	0.03	T	0	E	16	E	12	9
25	41	27	34	-5	31	T	T	T	N	9	E	56	6
26	42	28	35	-3	30	T	T	0	N	5	SE	9	9
27	42	23	33	-5	32	0.00	0.0	0	S	16	SE	100	6
28	40	22	31	-7	34	0.00	0.0	0	E	9	E	100	0
29	38	18	28	-10	37	0.00	0.0	0	N	6	N	100	0
30	38	17	28	-10	37	T	T	0	E	12	SE	51	10
31	44	35	40	+2	25	T	0.0	0	ESE	20	SE	37	10
Mean	46.4	31.4	[illegible]	-2.4	901	2.71	T		E	27	E	30	7.1
Normal			[illegible]		[illegible]	[illegible]							

PRESSURE	Mean		Highest		Date	Lowest		Date
Station	[illegible] in.	[illegible] mb.	[illegible] in.	[illegible] mb.	17	[illegible] in.	[illegible] mb.	7
Sea Level	[illegible] in.	[illegible] mb.	[illegible] in.	[illegible] mb.	17	[illegible] in.	[illegible] mb.	7

TEMPERATURE — Mean this month last year [illegible]. This month since 1943, warmest [illegible] in 1944, coldest [illegible] in 1946. Highest [illegible] date [illegible], lowest 17 date 30. This month since 1943 highest [illegible] date [illegible], lowest [illegible] date [illegible]. Average daily departure since Jan. 1 +2.2. Degree days since July 1 1513, normal [illegible], since Sept. 1 [illegible], normal [illegible]. Number of days: — Max. 100° or above 0; 90° or above 0; — Min. 32° or below 17; 0° or below 0; −10° or below 0. Normal number: — Max. 100° or above 0; 90° or above 0; — Min. 32° or below 9; 0° or below 0; −10° or below 0.

PRECIPITATION — Departure [illegible]. Total since Jan. 1 33.27. Dep. [illegible]. total since July 1 [illegible]. Dep. [illegible]. Total this month last year [illegible]. This month since 1943, wettest [illegible] in 1946, driest [illegible] in [illegible].

Greatest this month in: 5 min. .12 date 15; 10 min. .15 date 15; 15 min. [illegible] date 15; 20 min. [illegible] date 15; 30 min. [illegible] date 15; 1 hr. [illegible] date 15; 2 hr. [illegible] date 15; 24 hr. [illegible] date 21-22.

Greatest this month since 1943 in: 5 min. [illegible] date [illegible] 1943; 10 min. [illegible] date [illegible] 1943; 15 min. [illegible] date [illegible] 1943; 20 min. [illegible] date 22, 1945; 30 min. [illegible] date 22, 1945; 1 hr. [illegible] date 10, 1946; 2 hr. [illegible] date 10, 1946; 24 hr. [illegible] date 10, 1946.

SNOWFALL — Total since July 1 T. Dep. [illegible]. Greatest monthly, this month since 1943 [illegible]. Least monthly this month since [illegible]. Greatest in 24 hrs. T date [illegible]. Greatest any single storm T date [illegible]. Greatest on ground T date [illegible].

Number of days with precipitation: trace 7; 0.01 inch or more 15; 0.25 inch or more [illegible]; 1 inch or more 0; 2 inches or more 0. Normal number of days with precipitation: trace [illegible]; 0.01 inch or more [illegible]; 0.25 inch or more [illegible]; 1 inch or more [illegible]; 2 inches or more [illegible]. Greatest number of days this month since 1943 with precipitation 0.01 inch or more [illegible], least number [illegible].

CHARACTER OF DAY — Number of days clear 7; partly cloudy 4; cloudy 20. Normal number clear 2; partly cloudy 2; cloudy 26.
SUNSHINE — Total hours this month [illegible]. Total hours possible on 1st 11.5, on 16th [illegible], on last day [illegible], this month [illegible].
MISCELLANEOUS PHENOMENA (DATES) — Hail None. Sleet None. Glaze None.
Fog Light (5/16 - 6 mi.) None. Heavy (0-1/4 mi.) 16.
Frost Light None. Aurora Borealis 2, 3, 18, 28. Killing None.
Thunderstorms None. Lunar Halo 20, 30. Duststorms None. Tornadoes None. Hurricanes None.

Claude V. Brown
Official in Charge, Weather Bureau.

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STATION Juneau, Alaska (Airport) MONTH August 1950

APPENDIX N - 4 (B)

PSYCHROMETRIC DATA taken at twenty minutes past the hour.

Date	0430 Dry	0430 Wet	0430 Dew Pt.	0430 Rel. Hum.	1030 Dry	1030 Wet	1030 Dew Pt.	1030 Rel. Hum.	1630 Dry	1630 Wet	1630 Dew Pt.	1630 Rel. Hum.	2230 Dry	2230 Wet	2230 Dew Pt.	2230 Rel. Hum.
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MEAN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Normal																

WIND—Number of hours this month below 10 mi. .... 10 mi. and over .... 15 mi. and over .... 20 mi. and over .... 25 mi. and over .... 30 mi. and over .... 40 mi. and over ....

This Month—Dir.	N	NE	E	SE	S	SW	W	NW	DI	Month
Aver. Hrly. Vel.										
Percent of Time										

Maximum velocity this month since .... miles from .... on .... in ....

CEILING AND VISIBILITY FREQUENCIES (Based on hourly record observations) at ....

Visibility (miles)	Ceiling (feet) 0	100-300	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	Over 9500	Total
0 to ¼										
¼ to ½									2	2
½ to ¾									1	
1 to 2¾										
3 to 6					1	15	13	3	1	33
7 to 15						54	102	27	3	[illegible]
20 to 30						3	[illegible]	75	357	[illegible]
35 or more									30	[illegible]
Total					1	72	[illegible]	105	[illegible]	[illegible]

Frequencies for larger classes can be derived by addition, i.e., "Under 500 feet" from sum of 0, 100-300 and 300-400 classes; "7 miles or more" from sum of classes 7 to 15 miles or more inclusive.

FROST DATA—Average date of last killing frost in spring May 1; first in autumn October 2
Latest date of last killing frost in spring May [illegible], 19[illegible]; earliest in autumn August 25, 1948
Average growing season 152 days; longest 173 days in 1946; shortest 108 days in 1948

GENERAL SUMMARY—

The temperature for August averaged above normal. The first part of the month was dry but the rainfall during the last week brought the August total above normal.
There was more sunshine and less cloudiness on the average than normally was expected.

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STATION Juneau, Alaska (Airport) MONTH September 1950

APPENDIX N - 5 (B)

PSYCHROMETRIC DATA taken at twenty minutes past the hour.

Date	0430 Dry	0430 Wet	0430 Dew Pt.	0430 Rel. Hum.	1030 Dry	1030 Wet	1030 Dew Pt.	1030 Rel. Hum.	1630 Dry	1630 Wet	1630 Dew Pt.	1630 Rel. Hum.	2230 Dry	2230 Wet	2230 Dew Pt.	2230 Rel. Hum.
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MEAN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Normal																

WIND—Number of hours this month below 10 mi. .... 10 mi. and over .... 15 mi. and over .... 20 mi. and over .... 25 mi. and over .... 30 mi. and over .... 40 mi. and over ....

This Month—Dir.	N	NE	E	SE	S	SW	W	NW	DI	Month
Aver. Hrly. Vel.										
Percent of Time										

Maximum velocity this month since .... miles from .... on .... in ....

CEILING AND VISIBILITY FREQUENCIES (Based on hourly record observations) at ....

Visibility (miles)	Ceiling (feet) 0	100-300	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	Over 9500	Total
0 to ¼									1	
¼ to ½									1	
½ to ¾				4					7	7
1 to 2¾				2					5	
3 to 6							4	2	5	[illegible]
7 to 15				7		10	[illegible]	[illegible]	7	[illegible]
20 to 30						4	[illegible]	121	143	[illegible]
35 or more										
Total				10		16	317	[illegible]	167	720

Frequencies for larger classes can be derived by addition, i.e., "Under 500 feet" from sum of 0, 100-300 and 300-400 classes; "7 miles or more" from sum of classes 7 to 15 miles or more inclusive.

FROST DATA—Average date of last killing frost (frost or freeze) in spring May 1; first in autumn Oct. 2
Latest date of last killing frost in spring May 10, 19[illegible]; earliest in autumn August 25, 1948
Average growing season 152 days; longest 173 days in 1946; shortest 108 days in 1948

GENERAL SUMMARY— The month of September was above normal in the amount of rainfall and temperature. There was about the average amount of cloudiness and the amount of sunshine was slightly above normal. The first killing frost of the season occurred at the Airport on the morning of the 30th.

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STATION Juneau, Alaska (Airport) MONTH October 1950

APPENDIX N - 6 (B)

PSYCHROMETRIC DATA taken at twenty minutes past the hour

Date	0430 PST Dry	0430 PST Wet	0430 PST Dew Pt.	0430 PST Rel. Hum.	1030 PST Dry	1030 PST Wet	1030 PST Dew Pt.	1030 PST Rel. Hum.	1630 PST Dry	1630 PST Wet	1630 PST Dew Pt.	1630 PST Rel. Hum.	2230 PST Dry	2230 PST Wet	2230 PST Dew Pt.	2230 PST Rel. Hum.
1	31	31	27	75	41	40	39	96	53	48	43	70	36	35	34	94
2	30	30	29	97	45	42	39	81	54	48	43	65	35	35	34	96
3	29	29	26	95	42	39	32	68	49	46	43	80	[illegible]	[illegible]	40	95
4	40	39	38	92	43	42	41	91	49	46	43	81	35	35	34	96
5	36	36	35	96	41	[illegible]	42	96	50	46	42	71	42	[illegible]	42	96
6	40	39	37	95	47	[illegible]	43	86	48	46	44	86	42	[illegible]	41	95
7	46	43	41	82	45	[illegible]	44	94	48	47	45	91	47	[illegible]	45	92
8	45	44	43	92	46	[illegible]	44	93	48	46	44	86	46	[illegible]	[illegible]	96
9	45	43	41	85	46	43	41	85	46	44	42	87	[illegible]	[illegible]	[illegible]	[illegible]
10	41	[illegible]	[illegible]	95	45	44	[illegible]	92	46	44	42	86	[illegible]	[illegible]	43	90
11	45	44	43	90	45	44	42	89	46	44	42	86	45	44	42	90
12	44	43	42	92	45	44	43	[illegible]	45	44	43	71	44	43	42	96
13	45	42	40	82	46	43	42	92	40	44	40	73	42	41	[illegible]	92
14	40	40	40	95	43	41	39	86	46	43	40	78	39	36	37	95
15	42	41	40	91	41	40	39	93	44	42	40	75	[illegible]	[illegible]	37	92
16	37	36	36	95	38	37	36	91	46	43	40	79	[illegible]	[illegible]	[illegible]	93
17	26	25	25	95	34	32	29	83	48	45	42	78	[illegible]	27	24	86
18	25	25	23	91	32	31	28	86	46	39	28	50	28	28	26	92
19	23	23	21	91	32	30	28	79	40	37	32	71	37	35	31	80
20	37	36	35	92	38	37	35	86	44	38	36	56	41	41	34	92
21	42	40	38	86	41	40	39	90	40	39	38	92	36	36	34	93
22	35	35	34	96	34	34	34	97	38	36	32	79	27	26	24	89
23	26	25	22	83	36	32	25	64	37	33	27	66	34	33	32	93
24	36	35	34	91	39	37	34	83	41	38	35	79	34	33	32	93
25	30	27	20	[illegible]	30	29	[illegible]	91	37	34	29	74	32	31	28	87
26	32	31	29	89	35	34	32	89	39	37	34	83	31	30	26	[illegible]
27	26	26	24	92	31	29	25	79	39	33	22	51	31	28	22	[illegible]
28	33	29	21	62	31	29	24	74	35	30	20	53	25	24	21	85
29	20	20	17	88	26	25	21	82	33	28	17	50	21	20	16	81
30	[illegible]	[illegible]	25	85	27	25	21	77	35	31	23	[illegible]	35	33	30	80
31	36	35	33	96	37	36	34	89	38	37	35	88	36	36	34	89
MEAN	34.7	34.0	32.3	92	38.9	37.2	34.2	86	43.6	40.5	36.5	76	36.5	35.4	33.4	92
Normal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

WIND—Number of hours this month below 10 mi. .... 10 mi. and over .... 15 mi. and over .... 20 mi. and over .... 25 mi. and over .... 30 mi. and over .... 40 mi. and over ....

This Month—Dir.	N	NE	E	SE	S	SW	W	NW	DI	Month
Aver. Hrly. Vel.										
Percent of Time										

Maximum velocity this month since .... miles from .... on .... in ....

CEILING AND VISIBILITY FREQUENCIES (Based on hourly record observations) at ....

Visibility (miles)	Ceiling (feet) 0	100-300	300-400	500-900	1000-1900	2000-2900	3000-4900	5000-9500	Over 9500	Total
0 to ¼										
¼ to ½									1	1
½ to ¾									2	2
1 to 2¾									4	4
3 to 6							1	1	3	[illegible]
7 to 15					2	10	17	50	11	[illegible]
20 to 30						5	35	115	277	[illegible]
35 or more										
Total					2	15	212	162	393	744

Frequencies for larger classes can be derived by addition, i.e., "Under 500 feet" from sum of 0, 100-300 and 300-400 classes; "7 miles or more" from sum of classes 7 to 15 miles or more inclusive.

FROST DATA—Average date of last killing frost (frost or freeze) in spring May 1; first in autumn October 2
Latest date of last killing frost in spring May 15, 1946; earliest in autumn August 25, 1948
Average growing season 152 days; longest 173 days in 1946; shortest 108 days in 1948

GENERAL SUMMARY—October was a cool, dry month with temperatures and precipitation below normal. The coolest temperature of the month, 17 on the 30th was within 1° of the lowest on record for this month at the airport, the coolest, a temperature of 15, occurring on the 29th, 1945.

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WB FORM 1030

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

APPENDIX N - 7 (A)

MONTHLY CLIMATOLOGICAL SUMMARY

With Comparative Data

STATION Juneau, Alaska (Airport) MONTH November 19 50

Phone 011 ; 120 th Meridian Time; Lat. 58 ° 22 'N. Long. 134 ° 35 'W; Elevation 24.00 ft

DATE	Temperature °F: Maximum	Minimum	Mean	Departure from normal	Degree days base 65°	Precipitation: Total (inches)	Snowfall (inches) (unmelted)	Depth of snow on the ground	Wind: Prevailing direction	Highest velocity	Direction	Weather: Percent of possible sunshine	Average cloudiness scale 0 to 10
1	43	36	40	+4	25	0.08	0.0	0	SE	24	SE	7	10
2	46	39	43	+8	22	0.25	0.0	0	SE	28	SE	0	10
3	51	39	45	+11	20	0.59	0.0	0	SSE	22	SE	7	10
4	40	31	36	+2	29	0.11	0.8	0	SE	12	SE	15	10
5	33	26	30	-4	35	0.84	7.3	7	NE	8	SE	0	10
6	31	13	22	-12	43	T	T	7	N	7	NW	55	8
7	28	11	20	-13	45	0.00	0.0	6	N	11	N	100	0
8	31	13	22	-11	43	T	T	6	N	12	E	0	10
9	36	29	33	+1	32	[illegible]	2.3	5	E	13	E	0	10
10	39	32	36	+4	29	[illegible]	3.0	2	E	7	E	32	10
11	35	25	30	±0	35	T	T	2	N	17	N	76	5
12	39	23	31	-1	34	0.10	1.2	1	N	19	SE	2	10
13	23	10	17	-15	48	0.00	0.0	2	N	11	SE	100	0
14	25	12	19	-13	46	0.00	0.0	1	N	22	SE	35	9
15	19	11	17	-14	48	0.00	0.0	1	N	17	SE	83	2
16	17	13	15	-16	50	0.00	0.0	1	N	25	E	45	7
17	17	6	12	-19	53	0.00	0.0	1	NSE	22	E	100	0
18	24	5	15	-16	50	0.00	0.0	1	E	8	NE	69	3
19	29	7	18	-13	47	0.00	0.0	1	SE	23	SE	100	0
20	22	12	17	-14	48	0.00	0.0	T	E	17	E	100	0
21	18	7	13	-19	52	0.00	0.0	T	E	17	E	100	0
22	25	14	20	-12	45	T	T	T	ESE	24	SE	0	10
23	25	11	20	-12	45	0.05	1.5	1	N	22	SE	0	10
24	19	14	17	-15	48	0.03	1.0	2	N	15	SE	0	10
25	20	15	18	-14	47	0.07	2.6	3	N	6	E	0	10
26	20	5	14	-18	51	T	T	3	N	6	E	23	8
27	23	6	15	-15	50	0.00	0.0	3	N	17	SE	0	9
28	23	6	15	-15	50	0.00	0.0	3	N	10	N	0	10
29	23	4	14	-15	51	0.00	0.0	2	N	13	N	76	2
30	27	0	14	-15	51	0.00	0.0	2	N	9	N	100	1
31													
Mean	31.5	16.1	23.3	-7.7	1270	2.23	16.7		N	28	SE	42	6.5
Normal	-	-	32.0		797	5.40	-		-	-	-	-	-

PRESSURE	Mean		Highest		Date	Lowest		Date
Station	29.890 in.	1011.5 mb	30.520 in.	1033.3 mb	8	29.340 in.	993.5 mb	23
Sea Level	29.925 in.	1015.4 mb	30.648 in.	1037.5 mb	8	29.386 in.	994.1 mb	23

TEMPERATURE.—Mean this month last year 32.3. This month since 1943: warmest 39.6 in 1943; coldest 23.3 in 1950.
Highest 51, date 3; lowest 0, date 30. This month since 1943 highest 56, date 21, 1949; lowest -3, date 28, 1948.
Average daily departure since Jan. 1 -2.3 Degree days: since July 1 3113; normal 2920; since Sept. 1 2517; normal 2215.
Number of days:—Max. 100° or above 0; 90° or above 0;—Min. 32° or below 27; 0° or below 1;—10° or below 0.
Normal number:—Max. 100° or above 0; 90° or above 0;—Min. 32° or below 19; 0° or below 0;—10° or below 0.

PRECIPITATION.—Departure -3.17. Total since Jan. 1 55.20. Dep. -15.25; total since July 1 34.30. Dep. -5.04.
Total this month last year 9.22. This month since 1943: wettest 10.38 in 1944; driest 2.13 in 1950.

Greatest this month in:	Greatest this month since 1943 in:
5 min .02 date 3	5 min .08 date 2, 1949
10 min .03 date 3	10 min .13 date 2, 1949
15 min .03 date 3	15 min .14 date 2, 1949
20 min .05 date 3	20 min .19 date 2, 1949
30 min .06 date 3	30 min .19 date 2, 1949
1 hr. .09 date 3	1 hr. .26 date 1-2, 1949
2 hr. .15 date 3	2 hr. .46 date 1-2, 1949
24 hr. .60 date 2-3	24 hr. 3.34 date 1-2, 1949

SNOWFALL.—Total since July 1 28.7. Dep. -
Greatest monthly, this month since 1943 27.5, 1948
least monthly this month since 1943 0, 1943
Greatest in 24 hrs. 7.2 date 4-5
this month since 1943 7.2 date 4-5, 1950
Greatest any single storm 7.9 date 4-5
this month since 1943 7.9 date 4-5, 1950
Greatest on ground 7.0 date 5-6
this month since 1943 6.0 date 13, 1944

Number of days with precipitation: trace 5; 0.01 inch or more 11; 0.25 inch or more 4; 1 inch or more 0; 2 inches or more 0.
Normal number of days with precipitation: trace 4; 0.01 inch or more 20; 0.25 inch or more 9; 1 inch or more 2; 2 inches or more 0.
Greatest number of days this month since 1943 with precipitation: 0.01 inch or more 26 in 1944; least number 11 in 1950.

CHARACTER OF DAY.—Number of days clear 10; partly cloudy 2; cloudy 18. Normal number clear 3; partly cloudy 2; cloudy 25.
SUNSHINE.—Total hours this month 95.9. Total hours possible on 1st 11.9 on 16th 7.8; on last day 6.9; this month 235.9.
MISCELLANEOUS PHENOMENA (DATES).—Hail None; Sleet None; Glaze None
Fog: Light (5/16-6 mi) 11; Heavy (0-1/4 mi) 11
Freeze: Light None — Aurora Borealis 13, 28, 29; Killing None
Thunderstorms None; Duststorms None; Tornadoes None; Hurricanes None

a. City Office. b. Airport. c. Total. d. Monthly. e. Sunrise to sunset: 0 to 3, clear; 4 to 7, partly cloudy; 8 to 10, cloudy. f. other dates. g. Light fog, visibility 6 miles to 1,650 ft.; heavy, 1,649 ft. to 0. T indicates a trace of precipitation.

Claude V. Brown
Official in Charge, Weather Bureau

WB FORM 1030

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

APPENDIX N - 8 (A)

MONTHLY CLIMATOLOGICAL SUMMARY

With Comparative Data

STATION Juneau, Alaska (Airport) MONTH December 19 50

Phone 011 ; 120 th Meridian Time; Lat. 58 ° 22 'N. Long. 134 ° 35 'W; Elevation 24.00 ft

DATE	Temperature °F: Maximum	Minimum	Mean	Departure from normal	Degree days base 65°	Precipitation: Total (inches)	Snowfall (inches) (unmelted)	Depth of snow on the ground	Wind: Prevailing direction	Highest velocity	Direction	Weather: Percent of possible sunshine	Average cloudiness scale 0 to 10
1	30	15	23	-8	42	0.01	0.1	1	SE	24	SE	0	10
2	16	4	10	-21	55	0.00	0.0	1	N	8	N	100	0
3	19	1	10	-21	55	0.00	0.0	1	N	9	N	100	0
4	12	-2	5	-25	60	0.00	0.0	1	N	5	N	0	9
5	30	12	21	-9	44	0.69	10.4	9	N	8	N	0	10
6	36	27	32	+2	33	0.45	3.6	13	ESE	16	E	0	10
7	36	33	35	+6	30	0.09	0.0	9	ESE	21	SE	0	10
8	37	32	35	+7	30	0.01	0.0	6	E	16	E	13	9
9	39	32	36	+8	29	0.08	0.0	4	E	17	E	0	9
10	38	24	31	+4	34	T	0.0	3	E	14	E	35	8
11	31	20	26	-1	39	T	T	3	ESE	7	N	15	9
12	33	29	31	+4	34	0.13	0.4	3	ENE	4	SE	0	10
13	38	33	36	+9	29	0.13	0.0	3	E	15	E	0	10
14	36	28	32	+4	33	T	0.0	2	E	14	E	0	10
15	35	28	31	+2	34	0.05	0.8	2	N	3	N	0	10
16	32	22	27	-2	38	0.20	3.6	5	N	5	N	0	10
17	31	28	30	±0	35	0.03	0.2	5	N	4	N	0	10
18	32	24	28	-2	37	0.01	0.5	5	N	5	SE	0	10
19	35	24	30	±0	35	T	0.1	5	N	17	E	0	10
20	37	29	33	+3	32	0.15	1.3	7	E	15	SE	0	10
21	37	32	35	+6	30	0.21	0.9	5	E	19	E	0	10
22	37	28	33	+5	32	0.01	0.0	4	ESE	17	E	33	8
23	32	27	30	+3	35	0.31	3.4	5	NNE	6	SE	0	10
24	34	31	33	+7	32	0.26	3.2	11	E	5	S	0	10
25	38	31	35	+9	30	T	0.0	7	ESE	17	E	0	9
26	38	33	36	+10	29	0.12	0.0	4	ESE	22	E	0	10
27	38	32	35	+9	30	T	0.0	2	ESE	15	E	0	10
28	37	32	35	+9	30	0.09	0.0	2	ESE	21	SE	0	10
29	38	32	35	+10	30	0.13	0.0	1	E	14	E	0	10
30	35	25	30	+5	35	0.02	T	1	E	16	E	0	10
31	40	33	37	+12	28	0.25	T	1	SE	24	SE	0	10
Mean	33.4	25.1	29.3	+1.2	1099	3.43	28.5		E	24	SE	10	9.3
Normal	-	-	30.1		1114	4.13	-		-	-	-	-	-

PRESSURE	Mean		Highest		Date	Lowest		Date
Station	29.684 in.	1005.2 mb	30.075 in.	1018.4 mb	25	28.770 in.	974.2 mb	6
Sea Level	29.712 in.	1006.1 mb	30.101 in.	1019.3 mb	25	28.796 in.	975.1 mb	6

TEMPERATURE.—Mean this month last year 21.2. This month since 1943: warmest 37.0 in 1943; coldest 19.1 in 1948.
Highest 40, date 31; lowest -2, date 4. This month since 1943 highest 54, date 12, 1944; lowest -21, date 31, 1948.
Average daily departure since Jan. 1 -2.6 Degree days: since July 1 4212; normal 4032; since Sept. 1 3616; normal 3329.
Number of days:—Max. 100° or above 0; 90° or above 0;—Min. 32° or below 27; 0° or below 1;—10° or below 0.
Normal number:—Max. 100° or above 0; 90° or above 0;—Min. 32° or below 23; 0° or below 3;—10° or below 1.

PRECIPITATION.—Departure -.70. Total since Jan. 1 38.61. Dep. -15.75; total since July 1 27.61. Dep. -5.76.
Total this month last year 2.35. This month since 1943: wettest 9.86 in 1943; driest 2.35 in 1949.

Greatest this month in:	Greatest this month since 1943 in:
5 min - date -	5 min .03 date 31, 1947
10 min - date -	10 min .06 date 6, 1943
15 min - date -	15 min .08 date 6, 1943
20 min - date -	20 min .08 date 3, 1944
30 min - date -	30 min 0.12 date 6, 1943
1 hr. .09 date 6	1 hr. 0.18 date 17, 1943
2 hr. .16 date 6	2 hr. 0.35 date 17, 1943
24 hr. 0.83 date 5-6	24 hr. 1.44 date 16-17, 1943

SNOWFALL.—Total since July 1 45.2. Dep. -
Greatest monthly, this month since 1943, 35.9 in 1948
least monthly this month since 1943, 5.6 in 1944
Greatest in 24 hrs. 12.0 date 5-6
this month since 1943 12.6 date 19-20, 1948
Greatest any single storm 14.0 date 5-6
this month since 1943 14.1 date 19-20, 1948
Greatest on ground 13, date 6
this month since 1943 16.0 date 25-29, 1946

Number of days with precipitation: trace 6; 0.01 inch or more 22; 0.25 inch or more 5; 1 inch or more 0; 2 inches or more 0.
Normal number of days with precipitation: trace 4; 0.01 inch or more 22; 0.25 inch or more 6; 1 inch or more 0; 2 inches or more 0.
Greatest number of days this month since 1943 with precipitation: 0.01 inch or more 30 in 1943; least number 16 in 1946.

CHARACTER OF DAY.—Number of days clear 1; partly cloudy 0; cloudy 30. Normal number clear 3; partly cloudy 2; cloudy 26.
SUNSHINE.—Total hours this month 19.9. Total hours possible on 1st 6.9; on 16th 6.4; on last day 6.5; this month 201.1
MISCELLANEOUS PHENOMENA (DATES).—Hail None; Sleet None; Glaze None
Fog: Light (5/16-6 mi) 12, 13, 14, 16, 18, 19, 21, 24, 25, 26, 27, 30; Heavy (0-1/4 mi) 10, 14, 14, 19, 25, 26.
Freeze: Light None
Thunderstorms None; Duststorms None; Tornadoes None; Hurricanes None

a. City Office. b. Airport. c. Total. d. Monthly. e. Sunrise to sunset: 0 to 3, clear; 4 to 7, partly cloudy; 8 to 10, cloudy. f. other dates. g. Light fog, visibility 6 miles to 1,650 ft.; heavy, 1,649 ft. to 0. T indicates a trace of precipitation.

Claude V. Brown
Official in Charge, Weather Bureau

STATION.......Juneau, Alaska (Airport).......MONTH.......November.......1950

APPENDIX N - 7 (B)

PSYCHROMETRIC DATA taken at.......twenty minutes past the hour

Date	0430 PST Dry	0430 PST Wet	0430 PST Dew Pt.	0430 PST Rel. Hum.	1030 PST Dry	1030 PST Wet	1030 PST Dew Pt.	1030 PST Rel. Hum.	1630 PST Dry	1630 PST Wet	1630 PST Dew Pt.	1630 PST Rel. Hum.	2230 PST Dry	2230 PST Wet	2230 PST Dew Pt.	2230 PST Rel. Hum.
1	37	36	34	89	39	37	35	75	41	38	35	79	39	38	36	90
2	42	40	38	86	44	41	38	79	41	40	39	90	46	45	44	92
3	45	44	43	92	50	45	40	67	43	43	42	95	40	39	38	92
4	34	33	33	94	35	34	33	96	36	35	33	89	34	33	32	90
5	28	28	27	94	26	27	24	86	28	26	22	78	22	20	15	86
6	27	25	20	75	26	25	21	78	26	23	16	66	16	16	13	86
7	13	13	10	87	17	17	14	86	26	25	22	85	23	22	19	85
8	16	16	13	87	18	18	14	84	27	26	23	87	28	27	25	90
9	32	32	31	93	34	34	33	96	36	35	34	92	34	34	33	94
10	33	33	33	100	34	33	32	94	36	36	35	94	32	32	32	98
11	30	30	30	100	29	29	28	96	33	32	31	93	35	34	33	90
12	36	35	33	87	37	35	33	85	35	33	30	80	29	27	22	76
13	16	14	13	85	16	15	12	82	21	17	5	50	12	11	6	79
14	17	17	7	59	24	21	13	62	24	20	8	51	21	17	7	63
15	18	15	1	47	18	15	1	48	18	14	-6	34	15	12	-6	39
16	14	11	-6	41	15	13	4	60	16	14	6	64	14	12	-4	43
17	15	12	-6	37	15	12	-4	42	16	13	-2	45	8	7	-1	65
18	7	5	0	74	10	10	4	74	20	19	13	73	11	11	6	80
19	9	8	3	76	33	19	7	51	24	19	-2	32	17	15	-3	39
20	30	15	-10	25	30	15	-15	20	19	13	-15	19	15	11	-13	28
21	15	11	-13	27	14	10	-11	32	19	11	-7	36	16	12	-11	29
22	19	16	1	45	22	20	11	61	24	20	7	49	16	15	9	73
23	13	12	7	79	25	23	16	67	22	21	16	77	17	16	14	82
24	17	17	13	82	17	16	11	75	17	15	8	74	15	14	10	80
25	15	14	8	73	15	15	11	75	19	17	12	75	16	16	12	72
26	19	15	13	79	16	13	8	79	13	12	9	83	11	10	5	72
27	10	9	2	72	12	11	2	63	21	18	6	53	17	16	10	75
28	18	17	11	75	19	18	14	60	22	20	15	79	10	9	5	79
29	9	8	2	72	11	10	5	76	15	14	8	72	5	4	-1	77
30	2	2	-2	82	3	2	-5	70	10	10	6	65	17	16	14	80
31	20.9	19.4	15.9	74	22.6	21.1	14.3	72	21.7	22.6	14.7	69	21.5	20.1	13.6	73
MEAN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Normal																

WIND:—Number of hours this month below 10 mi.........: 10 mi. and over......: 15 mi. and over......: 20 mi. and over.......: 25 mi. and over.......: 30 mi. and over......: 40 mi. and over........

This Month—Dir.	N	NE	E	SE	S	SW	W	NW	Dl	Month
Aver. Hrly. Vel.										
Percent of Time										

Maximum velocity this month since........ ......miles from ...... on .... in ....

CEILING AND VISIBILITY FREQUENCIES (Based on hourly record observations) at........

Visibility (miles)	Ceiling (feet) 0	100–200	300–400	500–900	1000–1900	2000–2900	3000–4900	5000–9500	Over 9500	Total
0 to 1/4		1								1
5/16 to 5/8		5							1	7
3/4 to 7/8		5	1	5	5				2	19
1 to 2 1/2				2	1	14	4	3	3	24
3 to 6			1	1	7	5	33		2	51
7 to 15		1	1	5	1	12	21	14	27	106
20 to 30							14	47	210	123
35 or more										
Total		12	3	13	25	31	141	117	375	720

Frequencies for larger classes can be derived by addition, i.e., "Under 200 feet" from sum of 0, 100-200 and 300-400 classes; "7 miles or more" from sum of classes 7 to 35 miles or more inclusive.

(Frost or Freeze)

FROST DATA:—Average date of last killing frost in spring.......May 4.......: first in autumn.......Octo. 2.......
Latest date of last killing frost in spring.......May 10, 1944.......: earliest in autumn.......August 25, 1943.......
Average growing season.....152.......days: longest.......173.......days in 1946.....: shortest.......108.......days in [illegible]

GENERAL SUMMARY:— The month of November was cold and dry with more sunshine than is normally expected. All but 5 days, in the first part of the month, had below normal temperatures. The monthly mean was the lowest on record at the airport. The absolute low was within 3 degrees of lowest record, -3 degrees in 1946. The average amount of cloudiness was lowest on record at the airport, and more sunshine was recorded than during any time since 1943. Extremely gusty northeasterly winds from the 14th to the 16th, although not severe at the airport caused some damage in Juneau-Douglas area.

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STATION.......Juneau, Alaska (Airport).......MONTH.......December.......1950

APPENDIX N - 8 (B)

PSYCHROMETRIC DATA taken at.......twenty minutes past the hour

Date	0430 PST Dry	0430 PST Wet	0430 PST Dew Pt.	0430 PST Rel. Hum.	1030 PST Dry	1030 PST Wet	1030 PST Dew Pt.	1030 PST Rel. Hum.	1630 PST Dry	1630 PST Wet	1630 PST Dew Pt.	1630 PST Rel. Hum.	2230 PST Dry	2230 PST Wet	2230 PST Dew Pt.	2230 PST Rel. Hum.
1	35	34	13	53	30	25	18	65	28	27	24	86	20	20	17	87
2	8	8	4	86	5	5	1	84	17	12	8	83	6	5	1	76
3	6	5	-1	75	2	1	-4	77	13	12	5	70	6	6	0	74
4	0	0	-5	81	1	1	-3	84	8	6	3	80	11	11	7	82
5	18	17	14	82	22	22	20	92	27	26	24	89	28	27	25	91
6	28	28	27	96	30	30	28	92	35	34	33	92	35	34	33	93
7	35	34	33	91	35	34	32	88	35	34	32	89	35	34	32	91
8	37	36	34	89	35	34	33	93	34	34	33	95	33	33	32	96
9	36	35	33	89	36	35	33	91	35	34	33	94	36	35	34	92
10	35	34	32	90	34	34	33	95	33	32	31	92	27	27	22	81
11	25	25	22	94	21	21	18	86	29	28	26	90	30	30	30	93
12	31	30	29	92	31	31	30	97	33	32	31	95	33	32	32	95
13	33	32	32	96	35	34	33	92	37	35	35	93	37	35	35	91
14	34	34	33	96	33	32	31	94	31	31	30	96	29	29	28	96
15	30	29	29	100	30	30	29	97	33	32	32	94	31	31	30	94
16	31	30	29	91	29	28	26	90	27	27	26	90	28	28	27	95
17	29	29	28	94	29	29	28	95	31	30	29	93	29	29	26	94
18	29	28	27	91	29	28	27	92	31	31	30	96	30	30	29	96
19	30	29	28	95	27	27	25	93	28	27	25	94	32	30	28	86
20	30	30	29	94	31	30	29	93	37	35	33	86	37	35	32	83
21	34	33	32	93	32	32	31	90	34	33	31	90	35	34	32	92
22	35	34	33	90	36	35	33	90	34	33	32	93	31	30	28	87
23	27	27	26	95	30	30	29	96	32	32	31	96	32	32	31	97
24	31	31	31	97	32	32	31	96	33	33	32	96	33	33	33	97
25	34	33	32	92	35	34	32	90	35	34	33	91	33	32	32	96
26	33	33	33	97	36	35	34	91	36	35	33	90	36	35	34	92
27	37	36	35	91	38	36	33	83	34	34	33	95	34	33	32	96
28	34	33	32	91	34	33	33	96	37	35	33	87	37	35	33	93
29	34	34	33	96	34	33	32	92	34	34	33	96	34	33	32	95
30	25	24	21	87	36	35	33	87	34	33	32	90	35	34	32	92
31	35	34	33	91	35	34	33	91	35	34	33	[illegible]	36	34	[illegible]	[illegible]
MEAN	[illegible]	[illegible]	[illegible]	90	[illegible]	[illegible]	[illegible]	92	[illegible]	[illegible]	[illegible]	91	[illegible]	[illegible]	27.5	[illegible]
Normal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

WIND:—Number of hours this month below 10 mi.........: 10 mi. and over......: 15 mi. and over......: 20 mi. and over.......: 25 mi. and over.......: 30 mi. and over......: 40 mi. and over........

This Month—Dir.	N	NE	E	SE	S	SW	W	NW	Dl	Month
Aver. Hrly. Vel.										
Percent of Time										

Maximum velocity this month since........ ......miles from ...... on .... in ....

CEILING AND VISIBILITY FREQUENCIES (Based on hourly record observations) at........

Visibility (miles)	Ceiling (feet) 0	100–200	300–400	500–900	1000–1900	2000–2900	3000–4900	5000–9500	Over 9500	Total
0 to 1/4			2							2
5/16 to 5/8		2	4	4					2	12
3/4 to 7/8		3	1		2				2	[illegible]
1 to 2 1/2		1	1	10	50	13	3	3	2	83
3 to 6			1	3	21	23	28	1	1	[illegible]
7 to 15				1	11	14	215	66	[illegible]	[illegible]
20 to 30							44	32	109	[illegible]
35 or more										
Total		6	9	23	83	82	294	102	145	[illegible]

Frequencies for larger classes can be derived by addition, i.e., "Under 200 feet" from sum of 0, 100-200 and 300-400 classes; "7 miles or more" from sum of classes 7 to 35 miles or more inclusive.

FROST DATA:—Average date of last killing frost in spring.......May 1.......: first in autumn.......October 2.......
Latest date of last killing frost in spring.......May 10, 1944.......: earliest in autumn.......August 25, 1943.......
Average growing season.....152.......days: longest.......173.......days in 1946.....: shortest.......108.......days in [illegible]

GENERAL SUMMARY:— The month of December was warmer and drier with less sunshine than is normally expected. The first four days were much colder than the average and it was during this period that the lowest temperature of the month was recorded. With the exception of two days the remainder of the month was above normal. Although the month was drier than normal, the total monthly snowfall was above the average.

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APPENDIX O

TEMPERATURE AND PRECIPITATION SUMMARY AT ANNEX CREEK STATION

June - September, 1950

	Maximum Temp. (Degrees F.)				Minimum Temp.* (Degrees F.)			Precipitation (Inches)			
Day	June	July	Aug.	Sept.	June	July	Sept.	June	July	Aug.	Sept.
1	60	54	64	56	45	49	52	T	0.15	0.30	0.10
2	74	60	66	56	42	50	50		T	0.60	0.10
3	64	70	64	54	50	53	49	0.30	0.10	1.00	
4	72	70	66	54	49	56	49			1.20	0.20
5	80	68	64	52	49	52	48			0.80	
6	66	66	68	50	48	51	46	T	T	0.10	
7	82	70	70	50	48	53	48		T		
8	84	64	69	52	53	49	49		0.20		
9	78	68	73	50	49	52	44		T		
10	64	70	76	56	48	54	47		0.10		
11	80	66	70	55	50	52	49				
12	78	71	71	50	50	53	46		T		
13	80	72	69	50	48	52	46		0.15		
14	70	68	74	53	48	49	48		T		
15	78	66	75	52	49	51	49		0.10		1.15
16	80	68	74	50	49	53	46		0.40		2.60
17	79	67	72	48	50	53	45		1.13		2.30
18	76	68	75	47	48	54	44		1.20		3.20
19	77	65	69	48	50	49	45	T	0.60		1.15
20	61	64	66	50	48	48	46	0.18	0.80		2.80
21	67	66	60	48	49	50	43	0.10	0.20		2.40
22	70	68	63	49	50	49	40				1.15
23	76	70	60	50	60	50	41		T	T	0.80
24	69	67	58	49	52	56	39	0.15	T	0.20	1.10
25	70	67	56	47	54	57	38	0.10	0.10	0.40	1.10
26	69	69	53	50	49	56	36		T	1.20	0.40
27	68	66	54	48	48	54	34	0.10	T	0.80	T
28	70	64	56	49	49	53	32		1.10	1.40	
29	70	63	56	50	50	54	31	0.30	0.60	1.00	
30	72	65	52	49	49	53	31	0.20	0.80	1.60	
31		62	54			50			0.34	0.90	
Totals								1.43	8.07	11.50	20.65
Avgs.	72.7	66.5	65.1		49.4	52.1	43.7				

APPENDIX P

COMPARATIVE TEMPERATURE RECORDS AT TWO LEVELS IN THE KATABATIC AIR LAYER ABOVE THE NÉVÉ SURFACE, SITE 10B, 1950*(°F.)

Hour P.S.T.	26 July Level 4 ft.	26 July Level 36 ft.	27 July Level 4 ft.	27 July Level 36 ft.	28 July Level 4 ft.	28 July Level 36 ft.	29 July Level 4 ft.	29 July Level 36 ft.	30 July Level 4 ft.	30 July Level 36 ft.
0000	36	39	32.5	34	34	34.5	35.5	35.5	34	34
0100	35	38	32.5	34	34	35.5	35	35	33.5	33.5
0200	34	41	32	33	33.5	34.5	35	35	34.5	34.5
0300	34.5	37.5	32	32.5	33	34.5	35	35	34	34
0400	35	40	31.5	31.5	34.5	35	35	36	33.5	33
0500	35	36	32	31.5	34.5	35	35	35	33.5	33.5
0600	36	37	32.5	32	34.5	35.5	35	36	34	33.5
0700	37	38	35	33	35	35	35	36	35	34
0800	38	39	36	34.5	38	37	36	36.5	36.5	36
0900	38	39	39	38	39	38	37	37	36	36
1000	38	38.5	38	37	39	39	38	38	38	37
1100	38	38.5	46.5	43	38.5	38	37	39	39	39
1200	39	39	46	46	41.5	39	40	39.5	45	40
1300	38	39	46	50	41	39	39	39	43	43
1400	40	39.5	44	45	39	39	39.5	38	48	47.5
1500	40.5	40	41	40	40	39	39	38	41	42
1600	37	37	40	40	39	38	39	38	39	41.5
1700	37	37	40	42	39	38	37	36.5	38	39
1800	36	36	37	39	38	38	36.5	36	37	37
1900	35	36	37	37.5	35	36.5	36	36	38	37
2000	34.5	35	34.5	35	35	35.5	35	35	35	36
2100	34	34	35	35	36.5	36	34	34	34	35
2200	34	34.5	33.5	34	36	35	34	34	33	34
2300	33	35	33.5	33.5	36	36	34	34	32	33.5

Hour	31 July		1 August		2 August		3 August		4 August	
0000	31.5	33.5	34	37	33	36.5	36.5	41	35	38.5
0100	32	33	34	36	32.5	36	37	41	34	38
0200	33	33.5	34	37	32.5	35.5	36	39	35	38
0300	32	33	34.5	37	33	35.5	37	40	33.5	38
0400	32	33	35	39	33	36	35	39	35.5	38
0500	32.5	33	36	40	33.5	36	36	40	34	38
0600	33	33	35	36	34	37	36	38.5	35	38
0700	36	35	36	36.5	35.5	37.5	38	39	34	38
0800	37	35	37	36	36	38	38.5	40	36	39
0900	37.5	37	36	36	40.5	40	38	41	38	39.5
1000	37.5	36.5	37	36	44	43	38	43	37	38.5
1100	40	39	40	42	42	44	39	46	38.5	39
1200	44	44	40	42	40	49	39	45	40	43
1300	45	43	36.5	38	45	52	40	44	41	44
1400	39	40	39	38	40	48	41.5	46	41.5	46
1500	37	36	40	39	42	45	45	47	41.5	49
1600	37	36	38	39	41	44	43	44	40	44
1700	36	37	36.5	39	39	41	39	40	35.5	38
1800	36	36	36	39	39	42	36	41	[illegible]	39.5
1900	35.5	36.5	34	39	38	41	36.5	41	36	38
2000	35	36	34	37	37	40	35	40	34	38
2100	36	36	34	36	36.5	39	36	39.5	34	37
2200	35.5	36	33.5	36	35.5	38	35	39	34	35.5
2300	34	35.5	33.5	37	36	39	34	38.5	32	36

*From evaluation of micro-thermograph and glass thermometer records.

APPENDIX P (continued)

Hour	5 August Level		6 August Level		7 August Level		8 August Level		9 August Level	
P.S.T.	4 ft.	36 ft.	4 ft.	36 ft.	4 ft.	36 ft.	4 ft.	36 ft.	4 ft.	36 ft.
0000	33	37	38	43	34	42	37	48	40	52
0100	34	36	37	42	34.5	41	40	47	36	47
0200	35	37	38	44	35	40	41	48	39	52
0300	34	39	36	41	35	42	40	49	40	53
0400	33	37.5	37	40	36	42	39	48	38	48
0500	34	38	37	41	34	41	38	46	36	47
0600	36	40	36	39	35	41	41	48	40	47
0700	37.5	39	38.5	43	36	43	45.5	50	42	52
0800	39	43	37	42	38	44	45	50	43.5	52.5
0900	41	45	39	45	39	45	47.5	52.5	40	48
1000	39.5	45	38	43	40	45	49	53.5	41	53
1100	39	44	40	42	44	52	45	50	48	56
1200	40	43	43	48	41	49	45	50	52	58.5
1300	41	46	38.5	42	45	51	46	52	43.5	52
1400	40	45	39	44	42	49	44	50	42	49
1500	40	45	40	46	39	46	50	-	43	52
1600	40	45	38	44	41	48	42	-	42	48
1700	39	44	38	46	40	48	42	-	40	46
1800	37	43	37.5	47	40	51	41	-	39	44
1900	36	39	37.5	43	41.5	50	41	46	40	48
2000	36	38.5	36	42	40	48	40	49	41	51
2100	39	43	35	40	38.5	48	41	51	42	53
2200	41	44	36.5	39	38	45	43	54	40	52
2300	39	43	33.5	41	36.5	47	39	51	37	45

Hour	10 August		11 August		12 August		13 August		14 August	
0000	40	49	38	53	38	47	36	No	37	No
0100	39	50	40	49	39	48	36	Record	39	Record
0200	38	49	40	49	40	49	36	-	38	-
0300	36	43	39.5	49	39	48	36	-	40	-
0400	36	45	38	50	38	49	36	-	43	-
0500	38	49	41	52	39	50	35	-	45	-
0600	36.5	45	38	49	37	49	34	-	-	-
0700	39	50	40.5	50	36	47	33	-	46.5	-
0800	40	54	40	51	38	43	34	-	44	-
0900	40	55	42	53	39.5	50	35	-	45	-
1000	40	52	46	57	42	53	36	-	46	-
1100	41	55	45	55	41	55	37	-	47	-
1200	42	56	45	54	41	54	39	-	45.5	-
1300	43	55	43	51	41.5	No	42	-	49.5	-
1400	42	54	44	55	42	Record	45	-	42	-
1500	41	53	41	52	42	-	41	-	44	-
1600	42	54	40	57	41.5	-	43	-	43	-
1700	42.5	55	42	54	39	-	40	-	42	-
1800	42	54	42	54.5	41	-	40	-	40	-
1900	40	53	43	55	40.5	-	38	-	42	-
2000	39	52	41	56	40	-	35	-	42	-
2100	38	50	49	59	39.5	-	35	-	45	-
2200	40	51	43	54	38	-	34	-	46.5	47
2300	39	54	40	50	37	-	35.5	-	47	48

APPENDIX P (continued)

Hour	15 August Level		16 August Level		17 August Level		18 August Level		19 August Level	
P.S.T.	4 ft.	36 ft.	4 ft.	36 ft.	4 ft.	36 ft.	4 ft.	36 ft.	4 ft.	36 ft.
0000	42	47	32	48	38	46	39	40	36	42
0100	39	51	35	50	35	45	37	37	36	40
0200	41	52	31	46	33	44	40	40	35	38
0300	37	45	32	47	32	45	37	41	35.5	37
0400	40	50	32	51	31	45	41	45	36	39
0500	38	47	32	52	32	46	36.5	42	37	40
0600	39	50	34	53	30.5	49	39	44	38	41
0700	42	53	37	50	35	47	39	45	38.5	44
0800	44.5	52	41	53	39	51	40	46	39	43
0900	45	51	43.5	52	37	45	43	47	40	47
1000	44	52	39.5	50	38	44	45	46	44	50
1100	45.5	51	40	48	39	43	40.5	45	47	51
1200	40	50	43.5	48	40	44	46	44	41.5	52
1300	39.5	47	43.5	44	40.5	45	41	44	43	54
1400	39	44	44	45	40.5	43	41	41	43	50
1500	39	44	46	46	40	46	40	43	40	55
1600	40	45	42.5	49	38	42	41	44	40	52
1700	40	46	41	45	38	43	41	43	40	50
1800	40	45	40.5	47	38	44	41	43	38	49
1900	38	44	39.5	45	42	43	41	43	41	48
2000	34	43	39	43	40	42	39	42	40	47
2100	36	43	39	44	39.5	41	40	42	40	47
2200	34.5	46	38	45	40	43	38	42	41	48
2300	33	46	36	46	37.5	45	36	40	40	48

Hour	20 August		21 August	
0000	39.5	48	35	48
0100	37	52	34.5	48
0200	39	49	35	50
0300	40	54	35	47
0400	38.5	46	35	49
0500	41	46	35	45
0600	41.5	47	35	48
0700	38	48	37	49
0800	39.5	50	37.5	52
0900	41.5	52	38	53
1000	43.5	54	39	54
1100	41	55	40	55
1200	41	57	39	57
1300	38.5	50	41	54
1400	44	49	40	50
1500	44	55	41	47
1600	41.5	50	38.5	50
1700	41	48	39	49
1800	42	51	41	46
1900	40.5	52	40	48
2000	39.4	50	38	48
2100	38	49	36	47
2200	38	48	35	46
2300	36	49	35.5	47

APPENDIX Q

POSSIBLE DURATION OF SUNSHINE

Juneau, Alaska, (Airport) - Hours and Minutes

Date	June Possible Duration	July Possible Duration	August Possible Duration	September Possible Duration
1	17:50	18:10	16:30	14:01
2	17:52	18:09	16:26	13:56
3	17:54	18:07	16:20	13:51
4	17:57	18:05	16:16	13:45
5	17:59	18:03	16:12	13:41
6	18:01	18:02	16:07	13:35
7	18:04	17:59	16:03	13:30
8	18:06	17:56	15:58	13:26
9	18:08	17:54	15:54	13:21
10	18:09	17:52	15:48	13:16
11	18:11	17:49	15:44	13:11
12	18:13	17:44	15:38	13:05
13	18:15	17:43	15:34	13:00
14	18:16	17:39	15:29	12:55
15	18:16	17:36	15:25	12:50
16	18:18	17:33	15:19	12:45
17	18:18	17:30	15:14	12:40
18	18:19	17:26	15:10	12:35
19	18:19	17:22	15:05	12:30
20	18:19	17:19	15:00	12:25
21	18:19	17:15	14:56	12:20
22	18:19	17:12	14:50	12:15
23	18:18	17:08	14:45	12:10
24	18:18	17:04	14:41	12:06
25	18:18	17:00	14:36	12:00
26	18:17	16:54	14:31	11:55
27	18:16	16:52	14:26	11:50
28	18:15	16:48	14:20	11:45
29	18:13	16:44	14:15	11:40
30	18:12	16:38	14:11	11:34
31		16:34	14:06	

Note: Actual Durations in 1950 given as per cent of possible in Appendix N.

APPENDIX R

ANGLES OF OBSTRUCTION ABOVE HORIZON AT JUNEAU AIRPORT STATION AND AT CAMP 10

Given in averages over 5 - degree sectors

Sector (Degrees True) From To	Juneau Airport (Degrees)	Camp 10 (Degrees)	Sector (Degrees True) From To	Juneau Airport (Degrees)	Camp 10 (Degrees)
0 - 5	6	6	90 - 95	6	5
5 - 10	5	9	95 - 100	6	4
10 - 15	4	12	100 - 105	6	2
15 - 20	5	13	105 - 110	5	2
20 - 25	6	14	110 - 115	5	2
25 - 30	7	15	115 - 120	4	2
30 - 35	7	16	120 - 125	2	4
35 - 40	8	16	125 - 130	1	6
40 - 45	11	16	130 - 135	2	6
45 - 50	13	15	135 - 140	3	3
50 - 55	14	14	140 - 145	4	2
55 - 60	12	12	145 - 150	7	1
60 - 65	12	10	150 - 155	4	0
65 - 70	10	10	155 - 160	4	0
70 - 75	8	12	160 - 165	4	0
75 - 80	7	11	165 - 170	6	0
80 - 85	6	8	170 - 175	6	0
85 - 90	6	7	175 - 180	6	0

Note: 360 (degrees) is North and 180 (degrees) is South
Sunrise will vary from approximately 45 degrees to 135 degrees
Sunset will vary from approximately 225 degrees to 320 degrees

APPENDIX R (continued)

Sector (Degrees True) From - To	Juneau Airport (Degrees)	Camp 10 (Degrees)	(Degrees True) From - To	Juneau Airport (Degrees)	Camp 10 (Degrees)
180 - 185	6	0	270 - 275	2	0
185 - 190	7	0	275 - 280	3	2
190 - 195	7	0	280 - 285	2	3
195 - 200	6	0	285 - 290	2	4
200 - 205	5	0	290 - 295	4	4
205 - 210	4	0	295 - 300	4	2
210 - 215	2	0	300 - 305	3	0
215 - 220	2	0	305 - 310	3	0
220 - 225	3	0	310 - 315	4	4
225 - 230	2	0	315 - 320	4	6
230 - 235	2	0	320 - 325	4	6
235 - 240	2	0	325 - 330	3	7
240 - 245	2	0	330 - 335	3	7
245 - 250	2	0	335 - 340	3	7
250 - 255	1	0	340 - 345	5	8
255 - 260	2	0	345 - 350	5	8
260 - 265	2	0	350 - 355	6	8
265 - 270	2	0	355 - 360	6	6

APPENDIX S

SUMMERTIME HOURLY INSOLATION VALUES

Camp 10, elevation 3862 ft.
Lat. 58°39'N.; Long 134°12'W.

Date 1950	Intensity of Total Sky and Solar Radiation in Langleys* on horizontal surface during apparent solar hour ending at time shown							
	A.M.							
July	5	6	7	8	9	10	11	12
8					64.9	74.0	80.4	86.5
9				52.6	66.3	75.4	81.8	57.8
10			32.9	51.5	-----Recorder Trouble-------			
11	---------------------- no record -------------------------							
12			4.2	13.4	20.2	28.2	42.3	no record
13		(8.7)	14.8	23.0	36.2	64.2	79.4	81.1
14				34.1	40.7	50.1	-- no record --	
15			7.1	18.3	26.8	36.0	54.1	62.6
16		4.9	7.8	12.7	14.8	17.4	21.9	20.4
17		7.5	15.0	21.6	28.2	29.6	31.0	38.8
18	1.9	8.5	16.0	14.1	26.1	33.4	43.5	50.1
19	0.5	6.1	12.7	19.0	28.2	47.9	51.5	58.8
20	1.9	9.9	13.6	17.6	29.1	32.9	25.1	42.5
21		1.6	6.6	15.0	23.5	36.2	59.9	64.6
22		10.8	28.2	44.4	57.6	68.6	75.7	79.7
23		5.4	13.6	22.3	27.7	27.5	26.1	31.0
24	0.5	5.2	13.6	16.0	18.8	29.4	38.1	43.5
25		4.5	12.7	19.3	32.9	45.1	54.5	60.6
26		3.8	8.5	19.3	26.3	27.3	30.1	33.8
27		2.4	10.8	17.9	27.7	30.6	36.4	44.2
28		(5.6)	11.3	17.6	19.5	--	24.7	24.7
29	--------------------- no record -------------------							
30	4.0	9.2	14.6	22.1	41.6	57.3	51.7	63.5
31	3.1	8.5	16.5	27.5	43.7	41.6	58.8	67.7

*Gram calories per square centimeter

APPENDIX S

(Continued)

Date 1960 July	P.M. 1	2	3	4	5	6	7	8
8	[illegible]	[illegible]	70.0	[illegible]	43.7	[illegible]	[illegible]	[illegible]
9	78.7	61.1	61.1	46.5	32.7	14.1	3.5	
10	---- Recorder Trouble ------				33.8	17.6	4.9	
11	--------------------- no record --------------------------							
12	------ no record -----			27.3	13.6	10.8	3.8	
13	78.7	67.7	54.1	48.6	40.7	18.8	6.3	0.7
14	50.5	41.4	36.9	28.2	19.0	6.3	0.7	
15	60.2	48.6	34.5	23.0	12.9	6.6	0.9	
16	25.4	19.7	24.0	20.4	14.6	9.9	4.2	
17	44.7	33.1	28.2	15.5	12.2	8.5	4.2	1.9
18	57.6	53.1	49.4	37.6	20.7	11.3	5.4	1.2
19	54.1	53.1	41.6	23.0	13.6	9.2	3.5	0.2
20	43.0	31.7	24.9	13.6	12.7	6.3	1.9	
21	72.4	69.6	58.3	43.7	27.3	11.8	2.8	
22	70.5	59.9	44.2	33.8	22.3	12.0	5.6	0.7
23	29.4	27.0	27.7	20.7	14.8	7.8	2.8	
24	45.1	36.7	30.3	23.5	20.4	10.8	4.7	
25	44.7	43.2	32.4	23.0	18.3	16.5	3.8	0.5
26	33.1	23.5	25.4	19.7	11.8	7.8	5.2	
27	57.3	44.7	40.9	32.4	19.7	10.8		
28	32.9	22.1	16.5	12.9	6.6	3.5	(2.4)	
29	----------------- no record ------------------------							
30	55.0	40.9	32.0	26.8	28.9	20.2	12.7	2.1
31	59.9	62.0	50.1	39.5	27.3	16.9	10.6	3.8

APPENDIX S

(continued)

Date [illegible] Aug.	A.M. 5	6	7	8	9	10	11	12
1		[illegible]	7.1	14.1	27.3	39.7	33.4	34.3
2		2.8	7.8	18.3	29.1	47.7	--	--
3	----------	----------	----------	no record	----------	----------	----------	----------
4		3.5	7.8	12.2	14.8	20.7	27.7	32.0
5	----------	----------	----------	no record	----------	----------	----------	----------
6	----------	----------	----------	no record	----------	----------	----------	77.6
7		0.9	6.1	17.2	29.6	55.5	58.2	69.1
8				17.9	35.3	52.2	--	--
9	4.2	18.3	32.4	45.8	56.9	67.2	73.6	76.1
10			8.0	23.0	42.4	55.0	53.6	64.9
11	----------	----------	----------	no record	----------	----------	----------	----------
12		1.2	4.9	16.5	40.0	51.7	46.5	56.4
13	----------	----------	----------	no record	----------	----------	----------	----------
14		1.6	4.0	18.3	33.8	53.6	64.2	73.3
15	----------	----------	no record	----------	----------	----------	71.2	75.7
16		(5.9)	20.7	35.7	50.8	62.0	70.3	74.3
17			19.5	36.0	51.0	62.7	70.0	74.0
18	----------	----------	----------	no record	----------	----------	----------	----------
19			18.3	36.4	49.4	70.5	48.6	50.8
20	--	--	--	--	22.3	40.9	63.5	70.5
21 - 31	(no record)							

APPENDIX S

(Continued)

Date 1950 July	P.M. 1	2	3	4	5	6	7	8
8	84.1	[illegible]	70.0	58.8	43.7	26.8	11.8	0.9
9	78.7	61.1	61.1	46.5	32.7	[illegible]	3.5	
10	---- Recorder Trouble ------				33.8	17.5	4.9	
11	---------------------- no record --------------------------							
12	------ no record -----			27.3	13.6	10.8	3.8	
13	78.7	67.7	54.1	48.6	40.7	18.8	6.3	0.7
14	50.5	41.4	36.9	28.2	19.0	6.3	0.7	
15	60.2	48.6	34.5	23.0	12.9	6.6	0.9	
16	25.4	19.7	24.0	20.4	14.6	9.9	4.2	
17	[illegible]	33.1	28.2	15.5	12.2	8.5	4.2	1.9
18	57.6	53.1	49.4	[illegible]	20.7	11.3	5.4	1.2
19	54.1	53.1	41.6	23.0	13.6	9.2	[illegible]	0.2
20	43.0	31.7	24.9	13.6	12.7	6.3	1.9	
21	72.4	69.6	58.3	43.7	27.3	11.8	2.8	
22	70.5	59.9	44.2	33.8	22.3	12.0	5.6	0.7
23	29.4	27.0	27.7	20.7	14.8	7.8	2.8	
24	45.1	36.7	30.3	23.5	20.4	10.8	4.7	
25	44.7	43.2	32.4	23.0	18.3	16.5	3.8	0.5
26	33.1	23.5	25.4	19.7	11.8	7.8	5.2	
27	57.3	44.7	40.9	32.4	[illegible]	10.8		
28	32.9	22.1	16.5	[illegible]	6.6	3.5	(2.4)	
29	--- [illegible] record ------------------------------							
30	55.0	40.9	32.0	[illegible]	28.9	20.2	12.7	[illegible]
31	59.9	62.0	50.7	39.5	27.3	[illegible]	[illegible]	3.8

APPENDIX S

(continued)

Date 1950 Aug.	A.M. 5	6	7	8	9	10	11	12
1		3.3	7.1	14.1	27.3	35.7	33.4	[illegible]
2		2.8	7.8	18.3	29.1	47.7	--	--
3	------	------	------	no record	------	------	------	------
4		3.5	7.8	12.2	14.8	20.7	27.7	32.0
5	------	------	------	no record	------	------	------	------
6	------	------	------	no record	------	------	------	77.6
7		0.9	6.1	17.2	29.6	55.5	68.2	69.1
8				17.9	35.3	52.2	--	--
9	4.2	18.3	32.4	45.3	56.9	67.2	73.6	76.1
10			8.0	23.0	41.4	55.0	53.6	64.9
11	------	------	------	no record	------	------	------	------
12		1.2	4.9	16.5	40.0	51.7	46.5	56.4
13	------	------	------	no record	------	------	------	------
14		1.6	4.0	18.3	33.8	53.6	64.2	73.3
15	------	------	no record	------	------	------	71.2	75.7
16		(5.9)	20.7	35.7	50.8	62.0	70.3	74.3
17			19.5	36.0	52.0	62.7	70.0	74.0
18	------	------	------	no record	------	------	------	------
19			18.3	36.4	49.4	70.5	48.6	50.8
20	--	--	--	--	22.3	40.9	63.5	70.5
21 - 31	(no record)							

APPENDIX S

(continued)

Date 1950 Aug.	P.M. 1	2	3	4	5	6	7	8
1	56.9	41.4	30.3	21.9	15.5	9.9	2.8	
2	54.1	44.4	43.0	27.7	20.7	9.2	3.2	
3	no record							
4	33.8	no record						
5	no record							
6	77.1	72.9	65.8	53.1	34.8	19.3	6.1	0.7
7	70.5	60.6	65.8	55.0	40.0	13.2	4.7	
8	76.6	72.6	62.0	--	--	18.3	11.3	2.8
9	76.1	71.9	64.6	55.0	40.9	24.0	7.1	
10	70.5	51.2	no record					
11	72.1	--	--	43.0	24.0	8.2		
12	66.3	56.4	52.2	36.4	32.9	10.3	1.9	
13	no record							
14	76.6	74.0	67.7	57.1	43.0	24.7	9.4	0.9
15	75.9	70.5	60.2	47.5	32.0	16.5	2.8	
16	74.0	70.3	62.3	50.8	36.7	20.9	7.5	0.5
17	72.6	68.9	60.2	47.9	33.8	18.6	4.2	
18	73.3	68.6	57.1	42.3	25.4	10.6	0.9	
19	--	--	--	15.5	24.7	18.3	8.5	1.4
20	71.2	(62.5)	48.4	30.6	no record			
21 - 23	(no record)							
24	--	--	48.9	47.9	21.2	7.5	1.9	
25 - 31	(no record)							

APPENDIX S

(continued)

Date 1950 Sept.	A.M. 5	6	7	8	9	10	11	12
1 - 3	(no record)							
4	--------	--------	--------	record begins at 2 P.M.	--------	--------	--------	--------
5	--------	--------	--------	--------	--------	26.8	34.8	41.6
6						(58.8	77.6	57.6
7 - 10	(no record)							
11	--------	--------	--------	--------	21.9	(34.1)	--------	47.0
12					37.4	50.5	57.8	61.6
13			1.4	12.7	28.4	43.5	55.0	60.4
1951 Aug.								
20 - 23	(no record)							
24	--------	--------	--------	--------	24.0	36.2	35.3	39.5
25	--------	0.1	5.6	10.6	19.3	29.4	23.5	30.1
26	--------	2.8	9.2	19.3	41.4	50.8	60.6	64.9
27	--------	2.4	13.6	29.6	29.6	48.4	57.3	64.4
28	--------	--------	13.2	19.7	32.4	--------	--------	--------
29	--------	--------	14.1	26.3	33.8	48.4	57.3	42.8
30	--------	--------	--------	--------	28.2	46.5	57.3	62.0
31		1.9	13.6	26.8	34.3	48.6	55.9	60.2
Sept.								
1	--------	--------	10.6	24.4	37.6	48.9	56.4	61.1
2	--------	0.7	10.8	23.5	35.7	48.4	55.0	59.9
3			8.5	13.6	--------	--------	--------	--------
4	--------	1.4	11.3	24.9	36.2	45.1	54.3	58.8
5	(no record)							
6	--------	--------	--------	--------	11.3	15.5	--------	--------
7 - 13	(no record)							

APPENDIX S

(continued)

Date 1950 Sept.	1	2	3	P.M. 4	5	6	7
1 - 3	(no record)						
4	--------	--------	12.0	7.3	4.2	0.7------	-------
5	33.6	34.5	22.6	17.6	9.6	3.3	
6	49.4	38.8	26.3	16.9	9.4	3.8)	
7 - 10	(no record)						
11	54.5	37.6	46.1	31.0	21.2	5.2 ------	-------
12	61.6	58.5	51.2 --------	--------	--------	--------	--------
13	60.6	56.9	47.9	34.8	(21.2)	(6.3) ------	-------
1951 Aug.							
20 - 23	(no record)						
24	45.8	33.4	26.8	17.9	10.6	13.4 ------	-------
25	25.9	19.7	15.0	11.3	9.9	3.8	Trace
26	65.6	62.5	50.8	38.5	26.8	15.0	3.3------
27	60.2	55.0	55.5	39.5	28.7	16.5	5.6------
28	--------	60.6	54.5	44.2	31.5	17.4	5.2
29	53.1	59.7	51.7	41.4	26.3	7.1 ------	-------
30	62.7	59.7	52.2	41.4 --------	--------	--------	--------
31	61.1	58.5	51.5	40.4	25.9	10.3	0.5------
Sept.							
1	61.1	57.6	49.4	36.7	22.6	10.8	0.5------
2	60.2	53.6	42.8	--------	--------	6.6 ------	-------
3	--------	--------	--------	no record	--------	--------	--------
4	59.2	55.9	48.6	39.0	26.3	13.2	0.7------
5 - 9	(no record)						
10	--------	44.6	37.6	17.4	10.6 --------	--------	--------
11 - 13	(no record)						

APPENDIX T

I. REVISED AND EXTENDED LIST OF SURVEY STATIONS, 1950

Base Line Stations

Station 4: (Northeast end of Base Line) STATION TWIN - International Boundary Commission, and U.S. Coast and Geodetic Survey, third-order control station (1923)

Elevation: 4,668 ft.
Latitude : 58°36'11.880" N.
Longitude: 133°56'19.211" W.
Azimuth to NORRIS: 213°50' 16.0"
Distance to NORRIS: 68, 820 ft.

Summit of peak at south center of rim of "H" Basin (Camp 4 route). Lies north of Twin Glacier Lake, between East and West Twin Glaciers. Station marked by standard U.S.C. & G.S. bronze disk with two bronze markers nearby; also a rock cairn and remnant of a wooden tripod. Reached from notch in basin rim rock on route from Twin Glacier Lake to Camp 4.

Station 14: (South west end of Base Line) STATION NORRIS (on Norris Peak) U.S. Coast and Geodetic Survey third-order control station (1923)

Elevation: 4,125 ft.
Latitude : 58°26' 49.335" N.
Longitude: 134°08' 22.502" W.
Asimuth to Station TWIN: 34°00' 32.9"
Distance to Station TWIN: 68,820 ft.

On west side of Lower Taku Glacier between Taku and Norris Glaciers. Station marked by bronze disk on the southeast side of the flat summit dome of Norris Peak, but some 19 ft. lower than the true summit of the Peak. (14a) Rock cairn, with remnant of a wooden tripod. Approach from south side of mountain. (The coordinates given for these two base stations provide an accuracy of 0.1 ft.)

Station 14a: STATION TERMINUS (Norris Peak)
Elevation: 4,144 ft.

On true summit of Norris Peak. Marked by rock cairn. 277 ft. Northwest of Station NORRIS (14). Established in order to provide sights to the north which are not visible from Station NORRIS.

Description of Triangulation Network Stations Occupied or Positioned in 1950 to Extend the 1949 Control Network

Station 1:* (Camp 4, Basin Peak)
Elevation: 4,570 ft.

Approximately one-quarter mile north of Station 2

*1948 station for which elevation was determined in 1950

APPENDIX T

I. REVISED AND EXTENDED LIST OF SURVEY STATIONS, 1950 (continued)

Station 2:* (Camp 4, Basin Peak)
Elevation: 4,515 ft.

Approximately one-half mile north of Station 3

Station 3:* (Camp 4, Basin Peak)
Elevation: 4,750 ft.

Prominent ridge summit on east rim of "H" Basin and overlooking upper East Twin Glacier about one-half mile east of Camp III. (For location, see Plate I, J.I.R.P. Report No. 1.)

Stations 4 to 24 inclusive: noted in JIRP Reports No. 1 and No. 6.

Station 25: STATION LODGE (Taku Lodge)
Elevation : 24 ft.

Grease rock at Taku Lodge

Station 26: STATION HODGKINS (Hodgkins Peak or Mt. Hodgkins)
Elevation : 5,912 ft.

Established U.S. Geological Survey reference station, highest summit in "Organ Pipe Range". Lies 26,284 ft. southwest of Taku A and 21,064 ft. west of base STATION TWIN.

Station 26a: (South Peak, Mt. Hodgkins)
Elevation : 5,770 ft.

South summit of Mt. Hodgkins massif at south end of "Organ Pipe Range".

Station 27: STATION LOOKOUT ("Lookout Peak")
Elevation : 5,023 ft.

Summit of peak south of "Organ Pipe Range" and overlooking Taku Valley towards Taku Lodge. Lies 7,804 ft. south of Hodgkins Peak and 17,815 ft. southwest of STATION TWIN.

Station 28: STATION WEST ("West Peak")
Elevation : 5,337 ft.

Summit of peak overlooking and on west side of West Twin Glacier. Lies 15,138 ft. west of STATION TWIN and 6,144 ft. east of Hodgkins Peak. It is 5,301 ft. from Station 27.

Station 29: STATION ORGAN PIPE ("Organ Pipe Spire")
Elevation : 5,702 ft.

Strikingly serrated north summit of "Organ Pipe Range". Lies 21,135 ft. west of STATION TWIN and 22, 786 ft. east of Taku A (Station 31.)

*1948 station for which elevation was determined in 1950

APPENDIX T

I. REVISED AND EXTENDED LIST OF SURVEY STATIONS, 1950 (continued)

Station 30: STATION ANTLER ("Antler Peak")
Elevation : 5,829 ft.

High "horn-like" summit at northeast side of Upper East Twin Glacier, approximately 2.5 miles north of its ice fall and 16,360 ft. northeast of Base STATION TWIN. Rises as dominant peak in the "Horn Range" east and slightly north of Camp 4. No cairn. The theodolite was not set up on this station; however, it was fixed by triangulation from other points.

Station 31: STATION A ("Taku A")
Elevation : 4,954 ft.

On true summit of southern peak of Camp 10 massif. 9,938 ft. southeast of Camp 10 (Station 19). Identified by rock cairn on true summit.

Station 32: STATION B ("Taku B")
Elevation : 5,202 ft.

True western summit of Camp 10 nunatak adjacent to the Research Station. Lies 4,526 ft. northeast of Station 19 (Camp 10) and is identified by cairn.

Station 33: STATION C ("Taku C")
Elevation : 5,048 ft.*

Prominent rock summit of nunatak due northwest of Camp 10B and 17,513 ft. from Vantage Peak. 13,816 ft. northwest of Station 19 (Camp 10). Large rock cairn is 50 ft. west of exact summit.

Station 34: STATION EXPLORATION ("Exploration Peak")
Elevation : 5,907 ft.*

Prominent pyramidal summit mountain north and slightly west of Camp 10. 11,278 ft. from Station 32 and approximately 3 miles from summit of Vantage Peak.

Station 35: STATION BERGSCHRUND ("Bergschrund Spire")
Elevation : 6,625 ft.*

Position triangulated from other stations. Exact summit of "First Taku Range Peak". No cairn. Lower summit topped by cairn-like prominence of bedrock. Station used as turning point, but not occupied.

Station 36: STATION WESTWARD HO
Elevation : approximately 5,400 ft.

Precise control not established in 1950. Summit of prominent peak, 2 miles south of Camp 14. Large cairn, 50 ft. east of true summit.

*Recalculation advisable if using 1950 distance or elevation to extend control.

APPENDIX T

I. REVISED AND EXTENDED LIST OF SURVEY STATIONS, 1950 (continued)

Station 37: STATION GUARDIAN ("Guardian Peak")
Elevation : 5,193 ft.

Prominent tooth-like summit overlooking Norris Glacier drainage and on south side of West Branch, Taku Glacier. Approximately 5 miles (29,487 ft.) northwest of STATION TERMINUS at true summit of Norris Peak (base line site). No cairn, summit is sharp rock.

Station 38: STATION MIDWAY (Camp 14 munatak)
Elevation : (4500-4700)

Summit of Camp 14 nunatak. Precise location and elevation not yet determined.

Station 39: STATION AMHERST ("Mt. Amherst")
Elevation : ?

Prominent rock summit about 3 miles southwest of Camp 14 at extreme southern end of the "Taku Range". One of the peaks above "Echo Pass". Cairn on exact summit.

Station 40: STATION NUGGET ("Nugget Peak")
Elevation : 5,587 ft.*

Summit well marked by rock cairn north of Camp 16. Marked by a cross on U.S.G.S. Juneau B-2 sheet (1949). At head of Nugget Creek Glacier. Lies 40,854 ft. north and east of STATION JUNEAU.

Station 41: STATION SPLIT THUMB ("Split Thumb Peak")
Elevation : 5,536 ft.*

Prominent split summit approximately one mile east of Camp 16. Station at highest point. No cairn. 26,495 ft. north of MT. OLDS (Station 44)

Station 42: STATION CAIRN ("Cairn Peak")
Elevation : 4,542 ft.*

Summit on Glacier Highway-Camp 16 route at southwest edge of upper Lemon Glacier Névé. Lies directly above Salmon Creek Reservoir and 15,951 ft. from STATION JUNEAU to the south and west and 17,043 ft. from STATION OLDS. Well marked by prominent cairn on summit.

Station 43: STATION JUNEAU ("Mt. Juneau")
Elevation : 3,594 ft.*

U.S.G.S. bronze reference disk on southwest side of summit. High rock cairn on true summit. Approximately one mile north of Juneau and is easily reached by U.S. Forest Service trail. Lies 15,951 ft. south of STATION CAIRN on southwest side of ice field.

*Recalculation advisable if using 1950 distance or elevation to extend control.

APPENDIX T

I. REVISED AND EXTENDED LIST OF SURVEY STATIONS, 1950 (continued)

Station 44: STATION OLDS (Mt. Olds)
Elevation : 4,446 ft.*

Southeast summit of Mt. Olds. Not marked by cairn; however, there is a square bronze plate. 21,681 ft. easterly from Mt. Juneau (Station 43).

Station 45: STATION MICHAEL ("Michael's Sword")

Meta-volcanic tower close by west side of Devils Paw.

Station 46: STATION DEVILS PAW
Elevation : 8,548 ft. (8,584 ft. on I.B.C. map)

Prominent and highest summit at eastern rim of ice field. Series is Boundary Peak 93 of International Boundary Commission. Readily identified on all maps and photographs.

Station 47: STATION COULOIR ("Couloir Peak")
Elevation : 6,265 ft.

Summit of rugged mountain about one mile west of Michael's Sword. Northwest side of upper Twin Glacier Névé.

Station 48: STATION TAKU D ("Taku D")
Elevation : 5,815 ft.

Summit of prominent nunatak on northwest side of Camp 8 branch of upper Taku Glacier and nearly due west of "Exploration Peak" massif.

Station 49: STATION UNNAMED ("Unnamed Peak")
Elevation : 6,505 ft.

Summit of prominent mountain massif east and north of Camp 9 on eastern edge of short northwest-ward trending lobe of ice from the Taku Névé between TAKU D and E.

Station 50: STATION TAKU E ("Taku E")
Elevation : 5,490 ft.

Summit of nunatak nearly 3 miles northwest of Camp 9 and west of "Unnamed Peak".

Station 51: STATION NORTH ECHO ("North Echo Peak")
Elevation : 5,430 ft.

Northern summit of Camp 9 nunatak (close by Station 23).

Station 52: (First Berner's Bay Peak)
Elevation : 6,205 ft.

Summit of first prominent peak, two and one-third miles west of Camp 9 ("Snow King"), on north side of northwest Taku Névé.

*Recalculation advisable if using 1950 distance or elevation to extend control.

APPENDIX T

I. REVISED AND EXTENDED LIST OF SURVEY STATIONS, 1950 (continued)

Station 53: (Second Berner's Bay Peak)
Elevation : 6,365 ft.

Prominent peak, the second west ($3\frac{1}{2}$ miles) from Camp 9, on north side of N.W. Taku Névé.

Station 54: STATION TUSK ("The Tusk")
Elevation : 6,710 ft.

Striking, tusk-like summit a short distance northeast of Camp 15 on north side of N.W. Taku Névé. Nearly 5 miles west of Camp 9.

Station 55: STATION NORTH SNOWPATCH ("North Snowpatch Spire")
Elevation : 6,330 ft.

Summit of dominant peak south of Camp 15 between névés of Eagle and Herbert Glaciers. Six miles southwest of Camp 9.

Station 56: STATION SOUTH SNOWPATCH ("South Snowpatch Spire")
Elevation : 6,450 ft.

Southern summit of Snowpatch Spire massif (see Station 55)

Station 57: (Empress Peak)
Elevation : 7,115 ft.

Northwest summit of highest peak in western edge of ice field, overlooking Herbert Glacier Névé and at southwest end of range in which is Snowpatch Spire.

Station 58: STATION W. PROJECT (on "Project Peak")
Elevation : 6,815 ft.

Highest rock (west) summit of "Project Peak".

Station 59: STATION E. PROJECT (on "Project Peak")
Elevation : 6,785 ft.

Highest eastern rock point on summit ridge of "Project Peak".

Station 60: STATION S. TAKU TOWER ("South Taku Tower")
Elevation : 6,705 ft.

Sharp rock summit of S.E. Taku Tower

Station 61: STATION N. TAKU TOWER ("North Taku Tower")
Elevation : 6,750 (by 1949 survey)

Sharp rock summit of N.W. Taku Tower

APPENDIX T

I. REVISED AND EXTENDED LIST OF SURVEY STATIONS, 1950 (continued)

Station 62: STATION CATHEDRAL ("Cathedral Peak")
Elevation : 6,530 ft.

Highest rock summit of "Cathedral Peak"

Station 63: STATION MATTERHORN ("Little Matterhorn")
Elevation : 5,990 ft.

Station 64: STATION TRANSIT ("Transit Peak")
Elevation : 5,765 ft.

Small peak at north end of "Taku Range" at boundary between N.W. Taku Névé and the central Taku Névé.

II. GLACIER SURFACE ELEVATION PROFILE (by Micro-surveying Altimeter)

Southwest Transverse Surface Profile Across Taku Névé
(On line 222 degrees T. from Camp 10)

Location	Elevation (ft.)
Station B (Summit "Taku B")	5202
Station 19 (Camp 10)	3862
Moat below Camp 10	3570
Site 10A	3590
Site $10B_1$	3580
Site 10B	3575
Point, ½ mile southwest of 10B	3568
Point, 1 mile southwest of 10B	3596
Point, 1½ mile southwest of 10B	3588
Point, 2 miles southwest of 10B (Moat at base of north side of "Juncture Peak")	3578
Camp 14B (col on west side of "Juncture Peak" Pass)	3897
Station 21 ("Juncture Peak" summit)	4379

APPENDIX U

FIELD NOTES ON THE DETERMINATION OF FREE WATER PERCENTAGES IN SNOW AND FIRN

1. Non-calorimetric Method (after Bader)*

A. Principle

The method has several variants consisting of the measurement of the temperature depression introduced in a snow sample by the addition of a weak solution or by titrating a portion of the diluted solution drawn after mixing the snow. The field method described below only measures the temperature depression. Sodium hydroxide was used since it has a constant temperature depression coefficient at convenient concentrations: 3.41 , at 0.2 normal and 3.40 , at 0.5 normal.

B. Equipment

The following equipment is used:

1. Ordinary pint size thermos flask (wide mouthed if possible).
2. Balance to weigh to nearest ½ gram.
3. Thermometer graduated in 1/100 °C from + 0.1° to - 2.0°C. These thermometers are 12 inches long and are made specially by the Arthur H. Thomas Co., West Washington Square, Philadelphia 5, P.O. Box 779. The price is about $33.00.
4. A supply of small bottles each containing 99 grams (98 ml at room temperature) of NaOH of titer 0.297 normal.

C. Procedure

1. Immerse bottles of NaOH in snow slush to cool to 0°C. (Takes about 1/2 hour. NaOH at 0.297 normal and in 99 gram samples.)
2. The inside of the thermos flask is cooled to 0°C. by ice water which is then shaken out. The fraction of a gram left in the flask does not matter.
3. Weigh flask, add snow (about 100 grams); weigh flask again. Pour contents of small bottle into flask, stir with thermometer until all lumps of snow have disintegrated, and then read minimum temperature. (Takes less than one minute.) The thermometer may initially read a few hundredths of a degree lower than the equilibrium temperature which when it is reached will remain stable for one or two minutes. This stable temperature is the reading desired.

D. Computation

In the region of the concentration used, NaOH has a constant value of 3.405.

Taking the following equation with values x = grams liquid water; t = temperature depression; b = grams wet snow; c_o = grams solution added to snow; m_o = titer of solution c_o; B = temperature depression coefficient of solution.

*Bader, Henri; "Theory of Non-Calorimetric Methods for the Determination of the Liquid Water Content of Wet Snow", Schweiz. Min. Petr. Mitt., Vol. XXVIII, 1948, pp. 355-361.

$$X = \frac{B\, m_o\, c_o}{t} - c_o - 0.0062t\,(b + c_o)$$

We obtain $X = \frac{3.405 \times 0.297 \times 99}{t} - 99 - 0.0062t\,(b + 99)$

When snow b = 100 grams

$$X = \frac{100}{t} - 99 - 1.24t$$

The last term is approximately equal to 1, so $X = 100\,(\frac{1}{t} - 1)$

Therefore per cent liquid $H_2O = 100\,(\frac{1}{t} - 1)\,\frac{100}{b}$ (This is true when b = approximately 100 grams.)

E. Comment

Dr. Bader, by personal communication, advises that further laboratory tests of this method are planned by the Snow, Ice and Permafrost Research Establishment (Corps of Engineers) in order to check its application to refined analyses. It appears that some dielectric measurements recently carried forward by B. L. Hansen indicate that the energy absorption of a water film on ice crystals may introduce an error into calorimetric determinations as noted below. This matter is being investigated also.*

2. Calorimetric Method

This method is the one most commonly used. It is based on the determination of the latent heat of ice present in the ice-water mixture. A sample of wet snow is placed in a calorimeter containing hot water and the initial and final temperatures are observed. When one knows the mass of the sample of snow and the water equivalent of the calorimeter and water used, the mass of ice may be calculated directly from the temperature fall and the latent heat of melting of ice. Errors are often introduced, however, by faulty measurement of temperatures and by heat losses in the field calorimetric equipment. Therefore, to insure accurate measurement, considerable care must be used and all significant heat losses must be determined. For reference purposes, two useful field procedures which have been employed on the Juneau Ice Field are noted below.

A. Field Procedure for Approximate Values - Canadian Method**

1. Employ snow test kit, National Research Council of Canada, or equivalent instruments.
2. Put 300 grams hot water (between 50 and 60 degrees Centigrade) in the balance bucket and measure total weight.
3. Measure the water temperature using a thermometer of +100°C. to -10°C. range. (Do not use low-range thermometers since they will break if heated above upper limit.)

*Bader, Henri; "Note on the Liquid Water Content of Wet Snow", Journal of Glaciology, Vol. 1, No. 8, pp. 466-467.

**As used in measurements on the Juneau Ice Field, from method suggested by G.J. Klein, See National Research Council of Canada, Division of Mechanical Engineering, Report No. MM-192 and MM-202, 1946 and 1948.

4. Add sufficient snow to bring temperature to between 5° and 15°C. Stir the mixture to make sure that the snow is completely melted. Measure the final temperature and

5. Determine the weight of snow that has been added.

Let: W = weight of water
S = weight of snow
T_1 = initial temperature of water
T_2 = final temperature of mixture

Therefore, since it takes 80 calories to transform 1 gram of ice at 0°C. into water at 0°C., and since the temperature of wet snow is always 0°C., the weight of ice (I) in wet snow is:

$$(1)\ I = \frac{WT_1 - (W+S)\,T_2}{80}$$

Weight of Free Water therefore is S-I

(2) Therefore, Free Water Content (FWC) = $100\ (\frac{S-I}{S})$ per cent

Combining equations (1) and (2)

$$FWC = 100 - \frac{5}{4}\ (T_1 - T_2)\ \frac{W}{S}\ - \frac{5}{4}\ T_2$$

This calculation is facilitated by use of nomograms A and B in Report. MM-192 of National Research Council of Canada, Nov. 1946, (see previous footnote). An adjustment may be made for the heat losses introduced by the aluminum containers employed in this work. This is calculated on the basis of the specific heat of the metal.

B. U. S. Corps of Engineers Method for Calorimetric Measurements

The Snow, Ice and Permafrost Research Establishment of the Corps of Engineers, U. S. Army, has recently published a set of instructions for the field use of snow observers with limited experience. The method is one which has been evolved from the study of slightly different calorimetric techniques employed by the Pennsylvania Water and Power Co., the U. S. Weather Bureau, and by the early cooperative Snow Investigations of the Corps of Engineers and associated groups.* The procedure and pertinent information on this method are outlined in SIPRE Operation Manual No. 2, entitled, "Instructions for the Measurement of the Free Water Content in Snow", Snow, Ice and Permafrost Research Establishment, Wilmette, Illinois, Feb. 1952. (8 mimeographed pages, with sample computation sheet.) Since this is standard procedure recommended by a most competent group of snow specialists, it is recommended for future use on this project where the greatest accuracy is desired.

*See Gerdel, R. W., "Instructions for the Determination of Snow Quality", Technical Memo No. 1, Cooperative Snow Investigations, Corps of Engineers, San Francisco, California, 1944.

3. An Electrical Heating Method and Other Techniques

A survey of the methods used by a number of observers for the measurement of water content of wet snow has been prepared by I. G. Halliday in a recent issue of the Journal of Glaciology.* This writer especially discusses a method which employs an electrical heating coil as applied by Croce.** He suggests that this technique, together with Bader's non-calorimetric method, holds more promise than the standard calorimetric technique.

*Halliday, I. G., "The Liquid Water Content of Snow Measurement in the Field", Journal of Glaciology, Vol. 1, No. 7, 1950, pp. 357-361.

**Croce, K., "Bestimmung der Schneefeuchtigkeit", Arbeitsbericht A. 1 der Schneeforschungsstelle des Generalinspektors für das deutsche Strassenwesen (München) 1943. (Privately circulated; manuscript available at the British Glaciological Society.)

XV. ILLUSTRATIONS

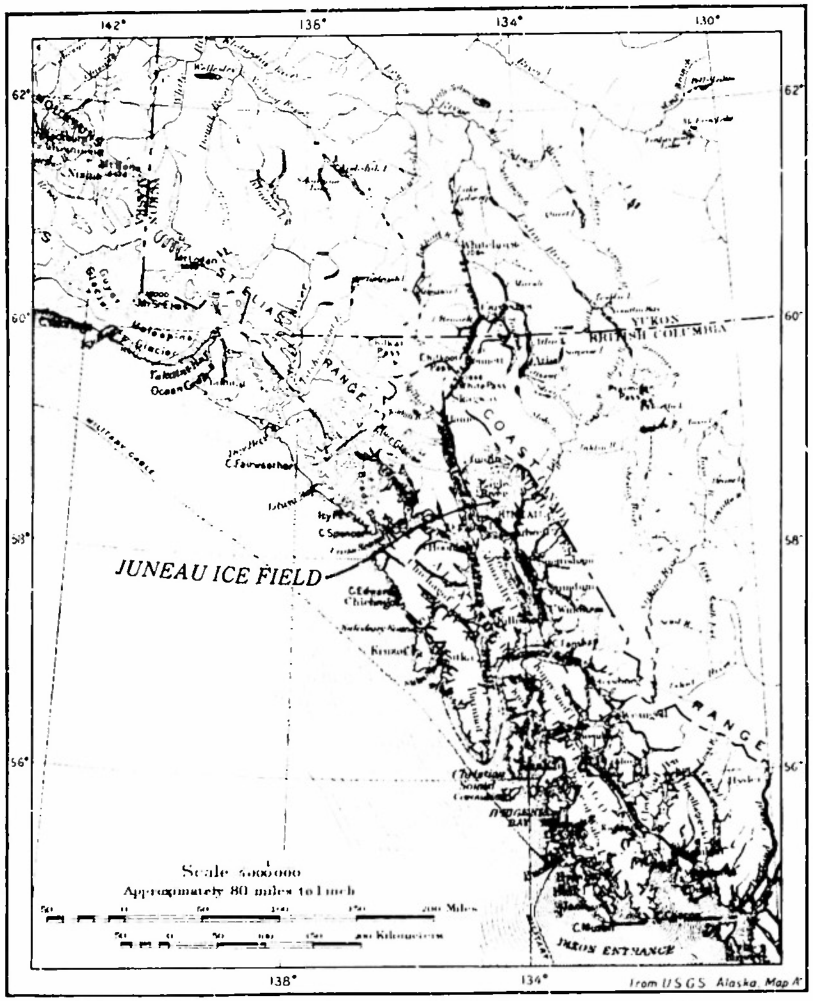


Fig. 1 - Location map of the Juneau Ice Field in Southeastern Alaska. Modified from the U. S. Geological Survey's "Alaska" Map A, 1:5,000,000.

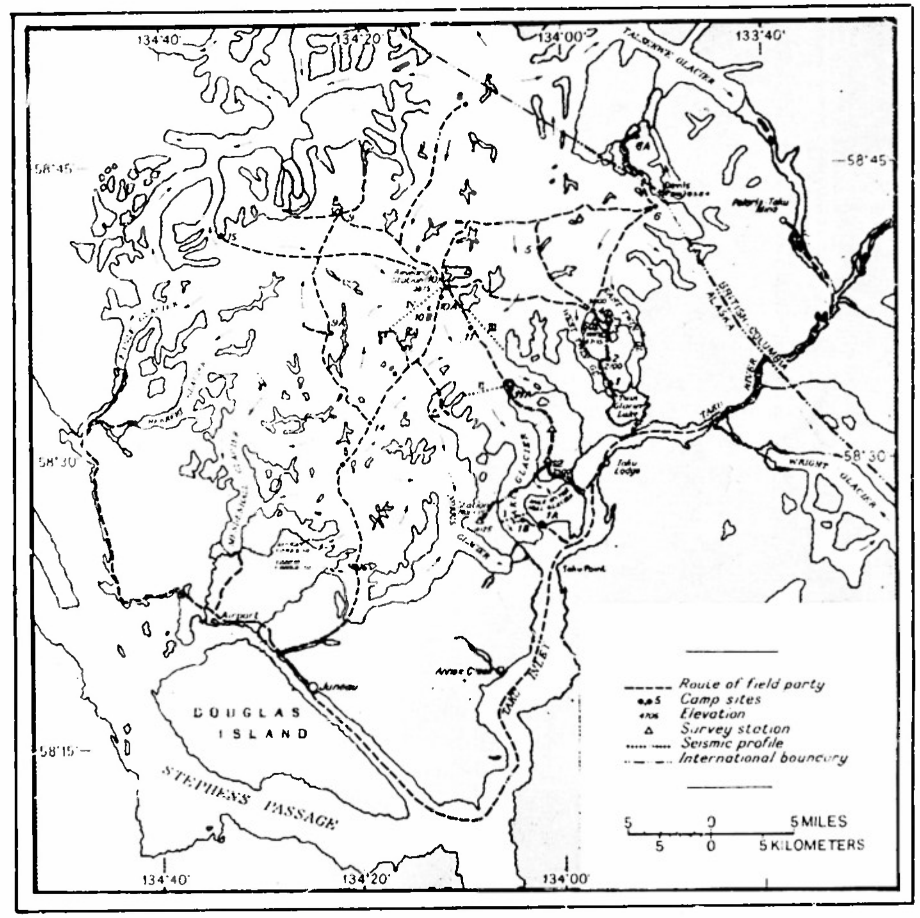


Fig. 2 - Sketch Map of the Juneau Ice Field and vicinity. Modified from map appearing in the Geographical Review, Vol. 40, 1950, p. 195.

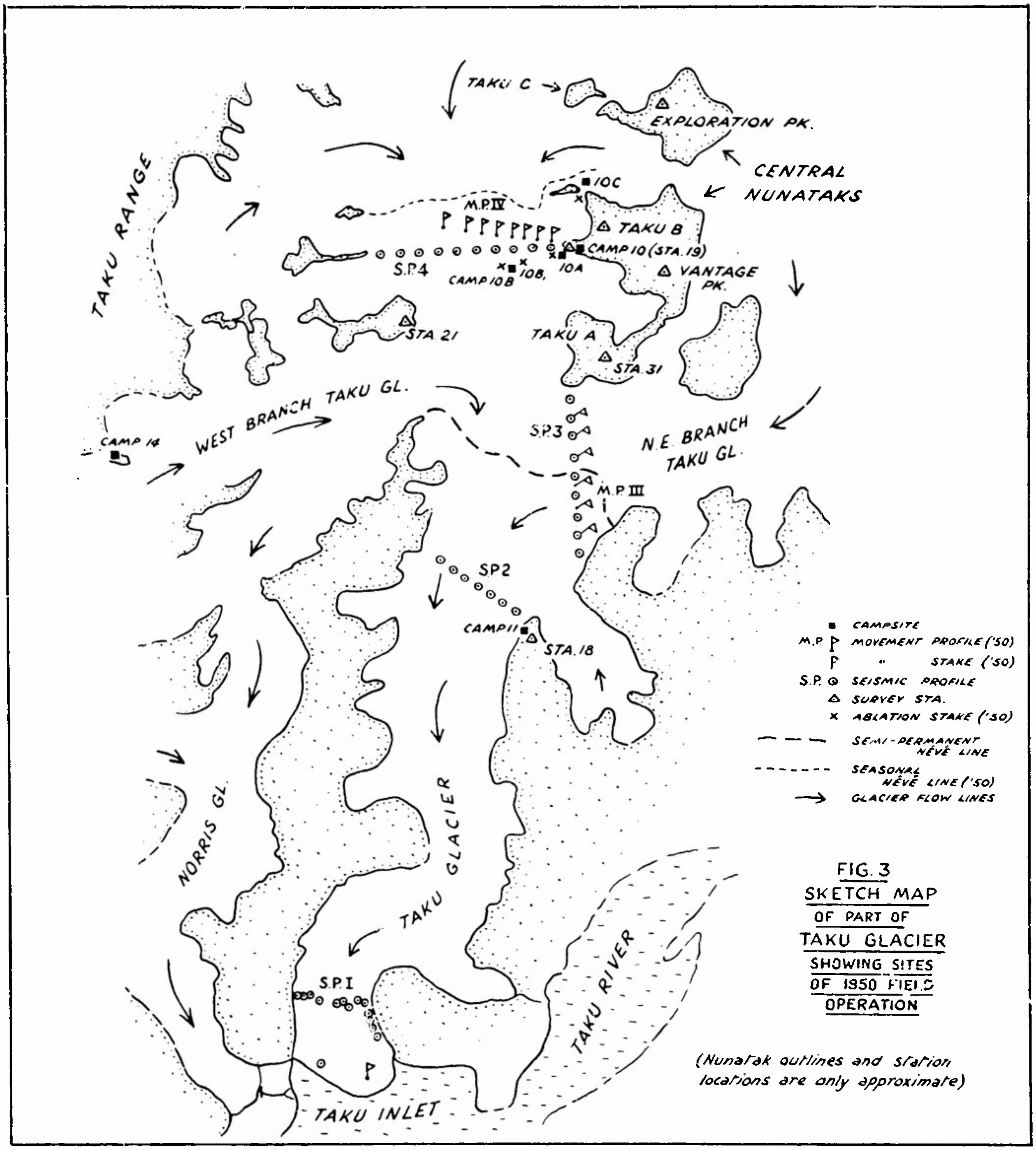
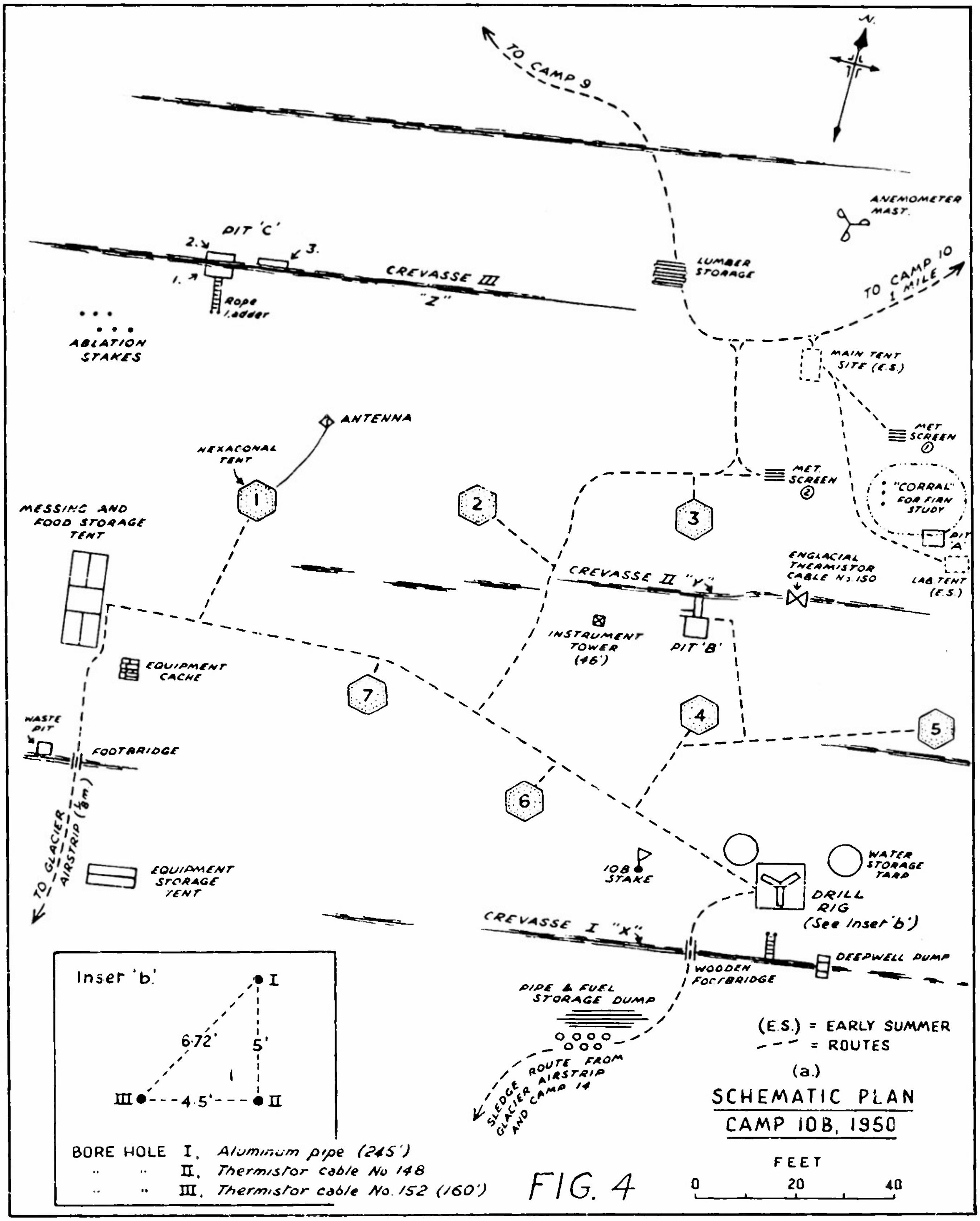
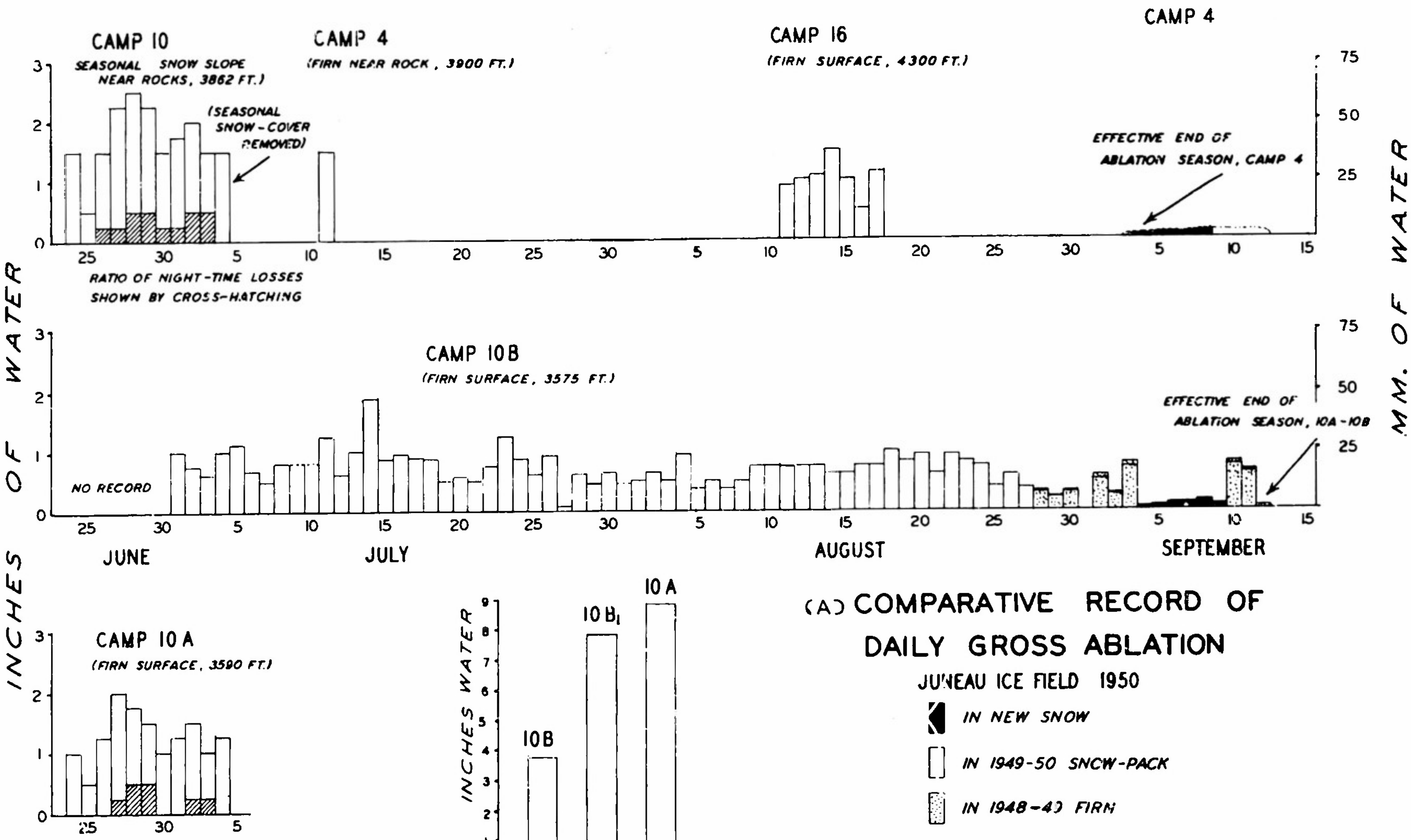


FIG. 3
SKETCH MAP
OF PART OF
TAKU GLACIER
SHOWING SITES
OF 1950 FIELD
OPERATION



TO CAMP 9
N.
ANEMOMETER MAST.
PIT 'C'
2.
3.
1.
Rope Ladder
CREVASSE III
"Z"
LUMBER STORAGE
TO CAMP 10 1 MILE
ABLATION STAKES
MAIN TENT SITE (E.S.)
ANTENNA
MET. SCREEN ①
HEXACONAL TENT
MET. SCREEN ②
"CORRAL" FOR FIRN STUDY
MESSING AND FOOD STORAGE TENT
1
2
3
PIT 'A'
LAB TENT (E.S.)
CREVASSE II "Y"
ENGLACIAL THERMISTOR CABLE No 150
INSTRUMENT TOWER (46')
PIT 'B'
EQUIPMENT CACHE
7
4
5
WASTE PIT
FOOTBRIDGE
6
TO GLACIER AIRSTRIP (1/8 m)
10B STAKE
WATER STORAGE TARP
EQUIPMENT STORAGE TENT
DRILL RIG (See Inset 'b')
CREVASSE I "X"
WOODEN FOOTBRIDGE
DEEPWELL PUMP
PIPE & FUEL STORAGE DUMP
SLEDGE ROUTE FROM GLACIER AIRSTRIP AND CAMP 14
Inset 'b'.
I
6.72'
5'
III
4.5'
II
BORE HOLE I. Aluminum pipe (245')
" " II. Thermistor cable No 148
" " III. Thermistor cable No. 152 (160')
(E.S.) = EARLY SUMMER
= ROUTES
(a.)
SCHEMATIC PLAN
CAMP 10B, 1950
FEET
0
20
40

FIG. 4

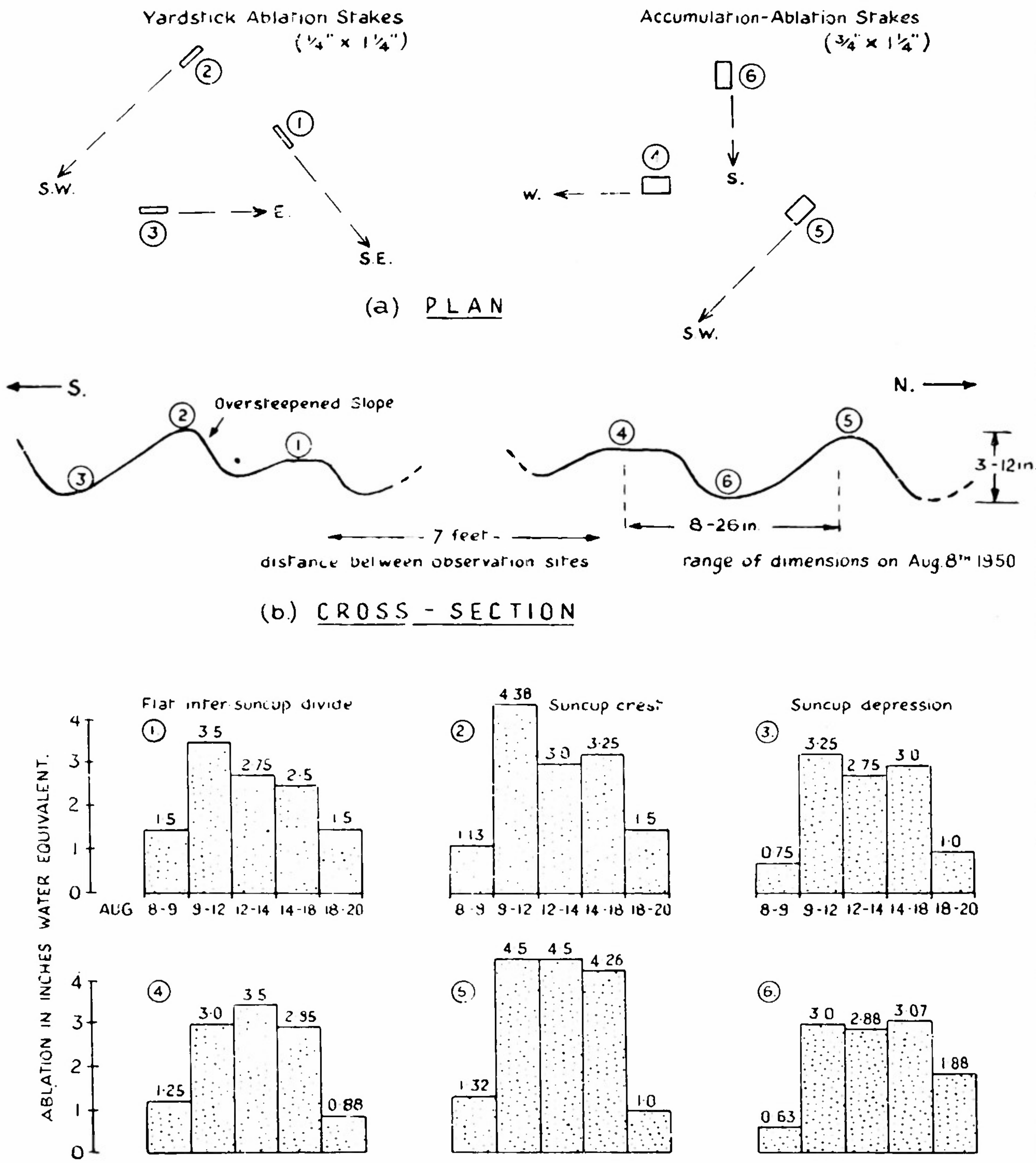


(A) COMPARATIVE RECORD OF DAILY GROSS ABLATION
JUNEAU ICE FIELD 1950

(B) SAMPLE OF COMPARATIVE GROSS ABLATION ON 12-HOUR BASIS. RATIO OF NIGHT-TIME LOSSES SHOWN BY CROSS-HATCHING.

(C) AUGUST 9 TO 14, AGGREGATE VALUES OF GROSS ABLATION FROM EDGE TO CENTER OF TAKU NÉVÉ, VICINITY MAIN BASE CAMP.

FIG. 5



(c) Comparative ablation in designated parts of two sets of suncups over corresponding periods in August, 1950. Camp 10B névé, Taku Glacier, Alaska.

FIG. 6

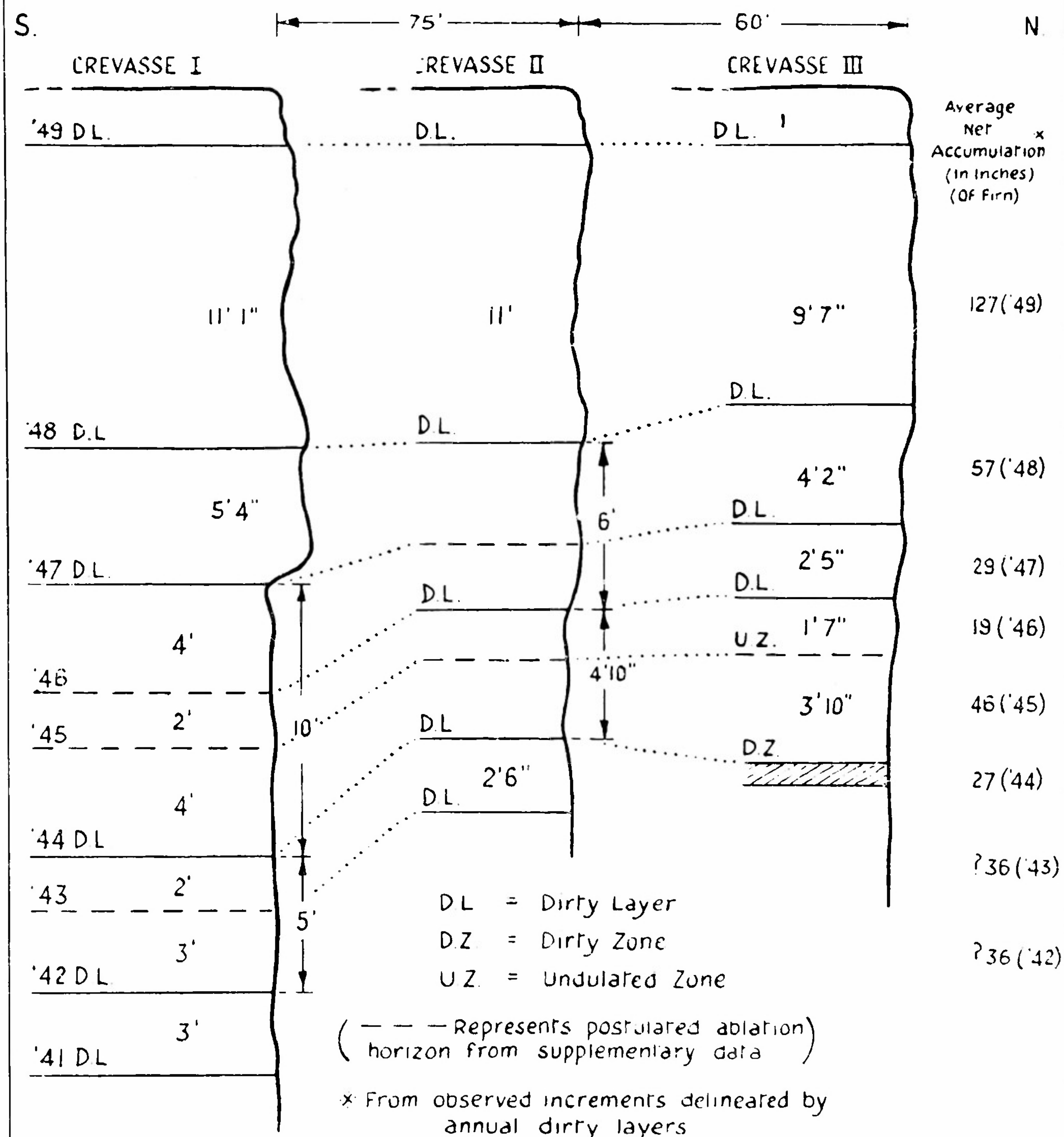


FIG. 7 PROBABLE CORRELATION OF THREE CREVASSE WALLS, CAMP 10B (See Fig.3)

Showing relationship of observed annual dirty layers at depth as measured on Aug. 11th 1950

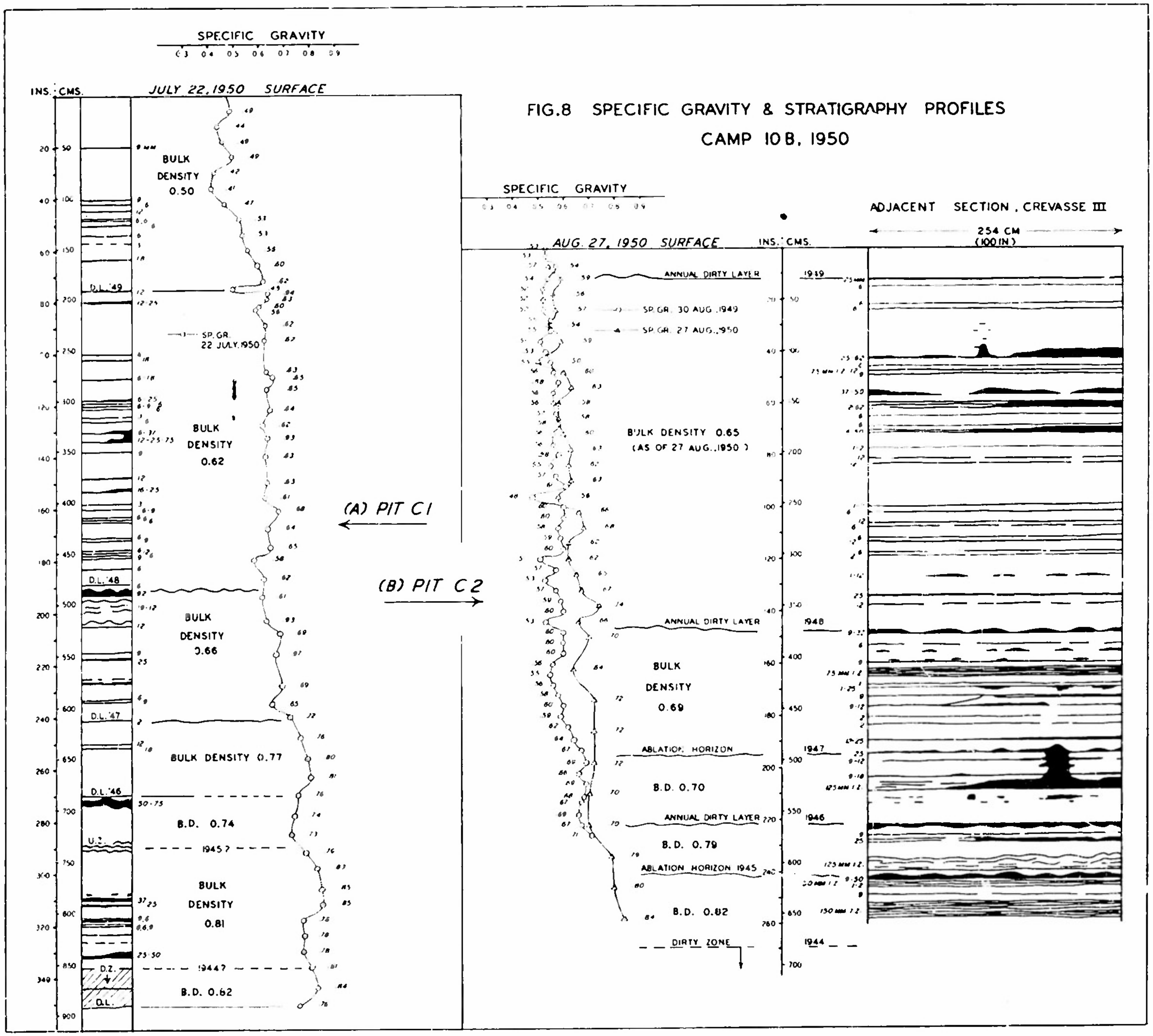
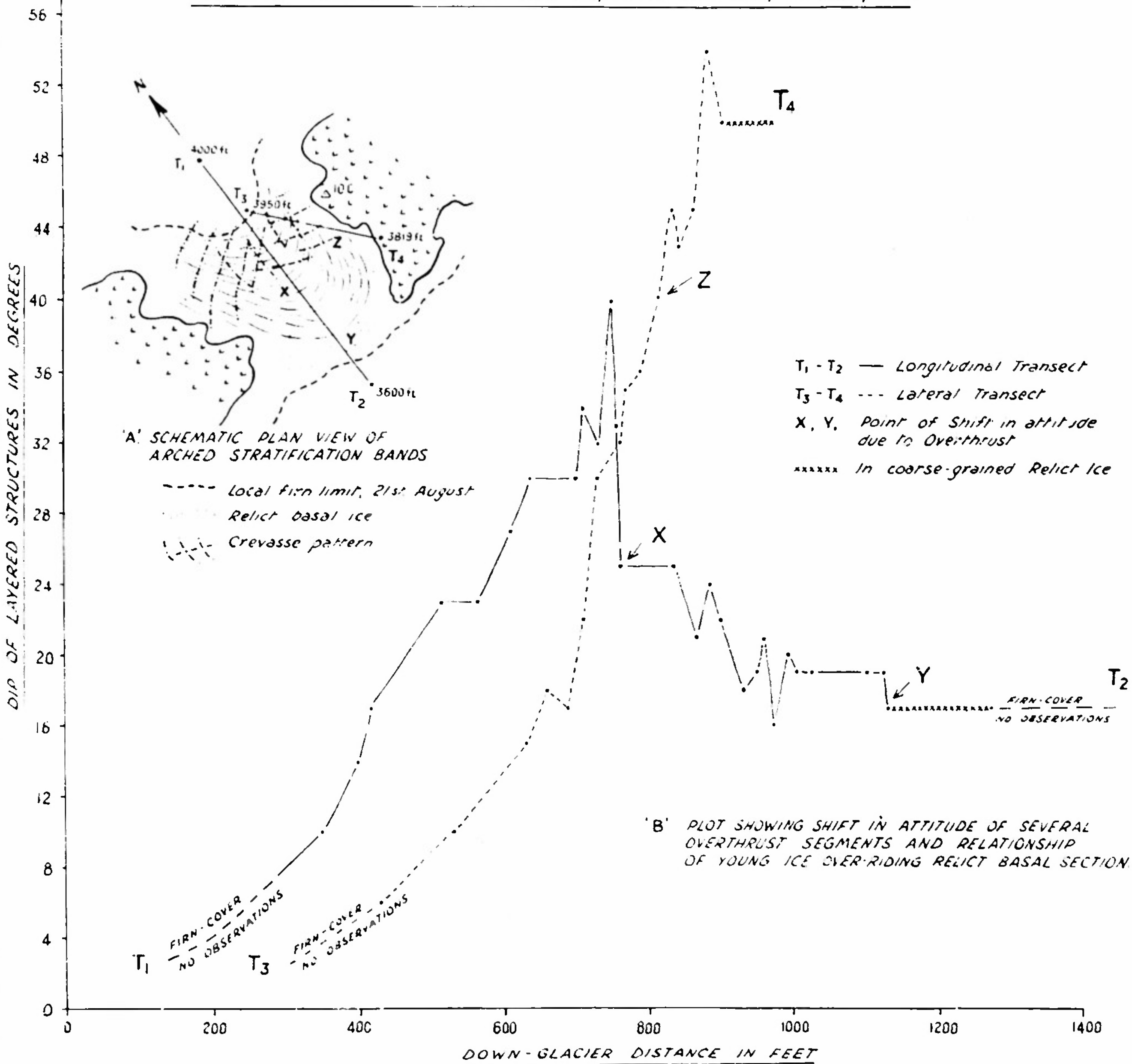


FIG.8 SPECIFIC GRAVITY & STRATIGRAPHY PROFILES
CAMP 10B, 1950

FIG. 9 TRUE DIP OF PRIMARY STRATIFICATION ALONG TWO PROFILES IN A HIGHLAND LOBE OF THE TAKU GLACIER, NEAR SITE 10c, AUGUST, 1950.



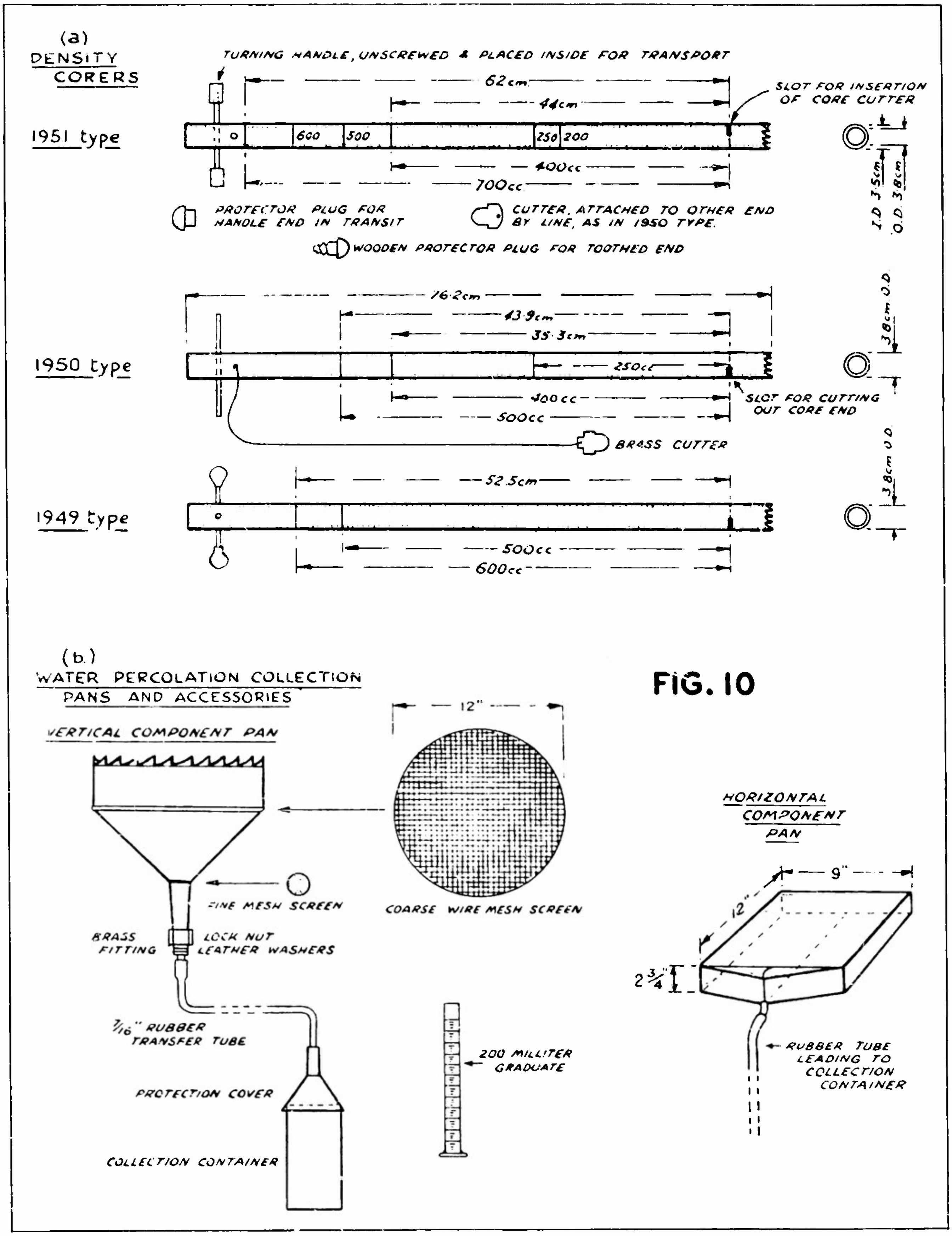

(a)
DENSITY CORERS
TURNING HANDLE, UNSCREWED & PLACED INSIDE FOR TRANSPORT
62cm
44cm
SLOT FOR INSERTION OF CORE CUTTER
1951 type
600
500
250
200
400cc
700cc
I.D 3.5cm
O.D. 3.8cm
PROTECTOR PLUG FOR HANDLE END IN TRANSIT
CUTTER, ATTACHED TO OTHER END BY LINE, AS IN 1950 TYPE.
WOODEN PROTECTOR PLUG FOR TOOTHED END
76.2cm
43.9cm
35.3cm
1950 type
250cc
3.8cm O.D
400cc
500cc
SLOT FOR CUTTING OUT CORE END
BRASS CUTTER
52.5cm
1949 type
3.8cm O.D
500cc
600cc
(b.)
WATER PERCOLATION COLLECTION PANS AND ACCESSORIES
VERTICAL COMPONENT PAN
12"
FINE MESH SCREEN
COARSE WIRE MESH SCREEN
BRASS FITTING
LOCK NUT
LEATHER WASHERS
7/16" RUBBER TRANSFER TUBE
PROTECTION COVER
COLLECTION CONTAINER
200 MILLITER GRADUATE
HORIZONTAL COMPONENT PAN
9"
12"
2 3/4"
RUBBER TUBE LEADING TO COLLECTION CONTAINER

FIG. 10

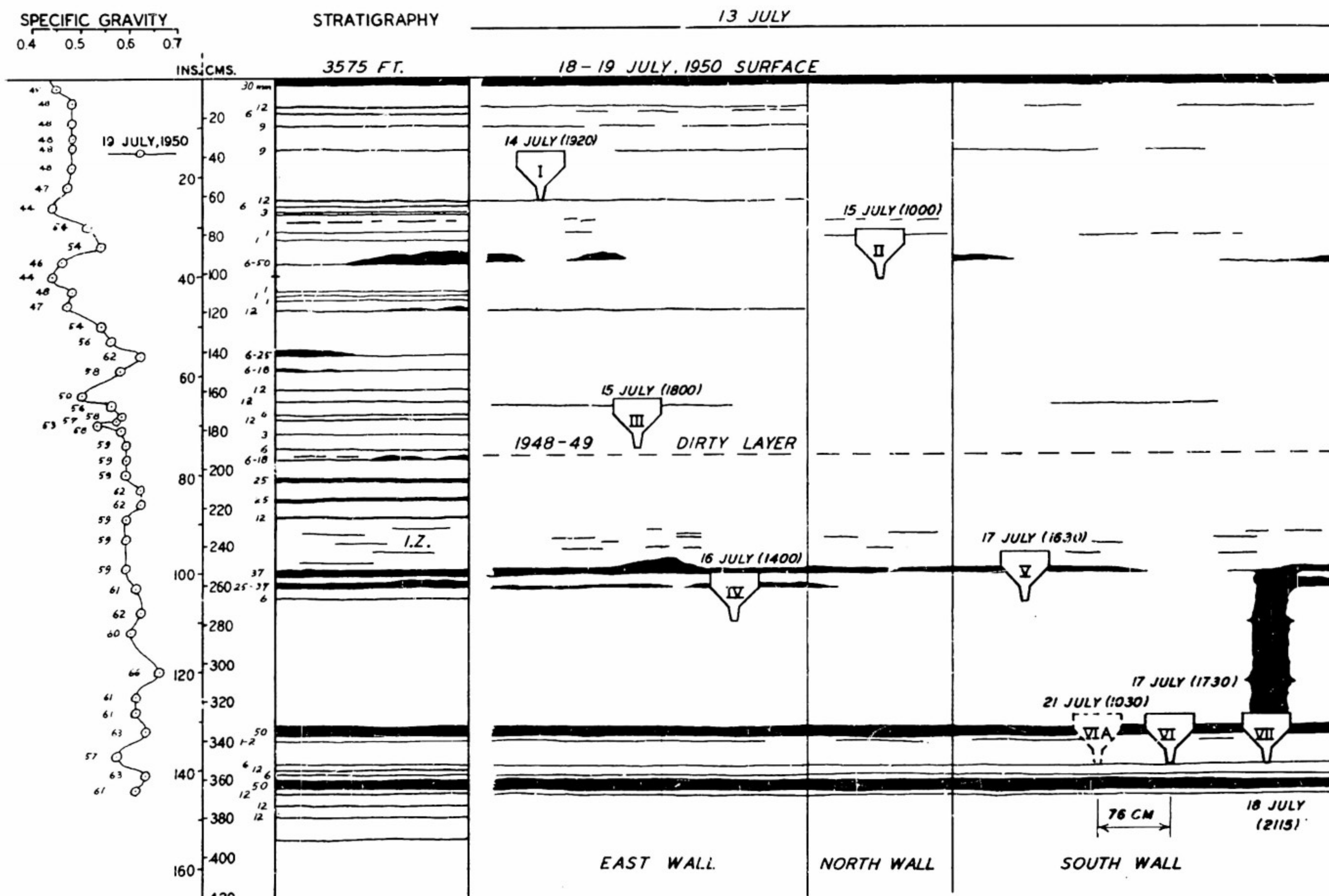


FIG. II SPECIFIC GRAVITY, STRATIGRAPHY, AND POSITION OF PERCOLATION PANS
PIT A, CAMP 10B, 1950

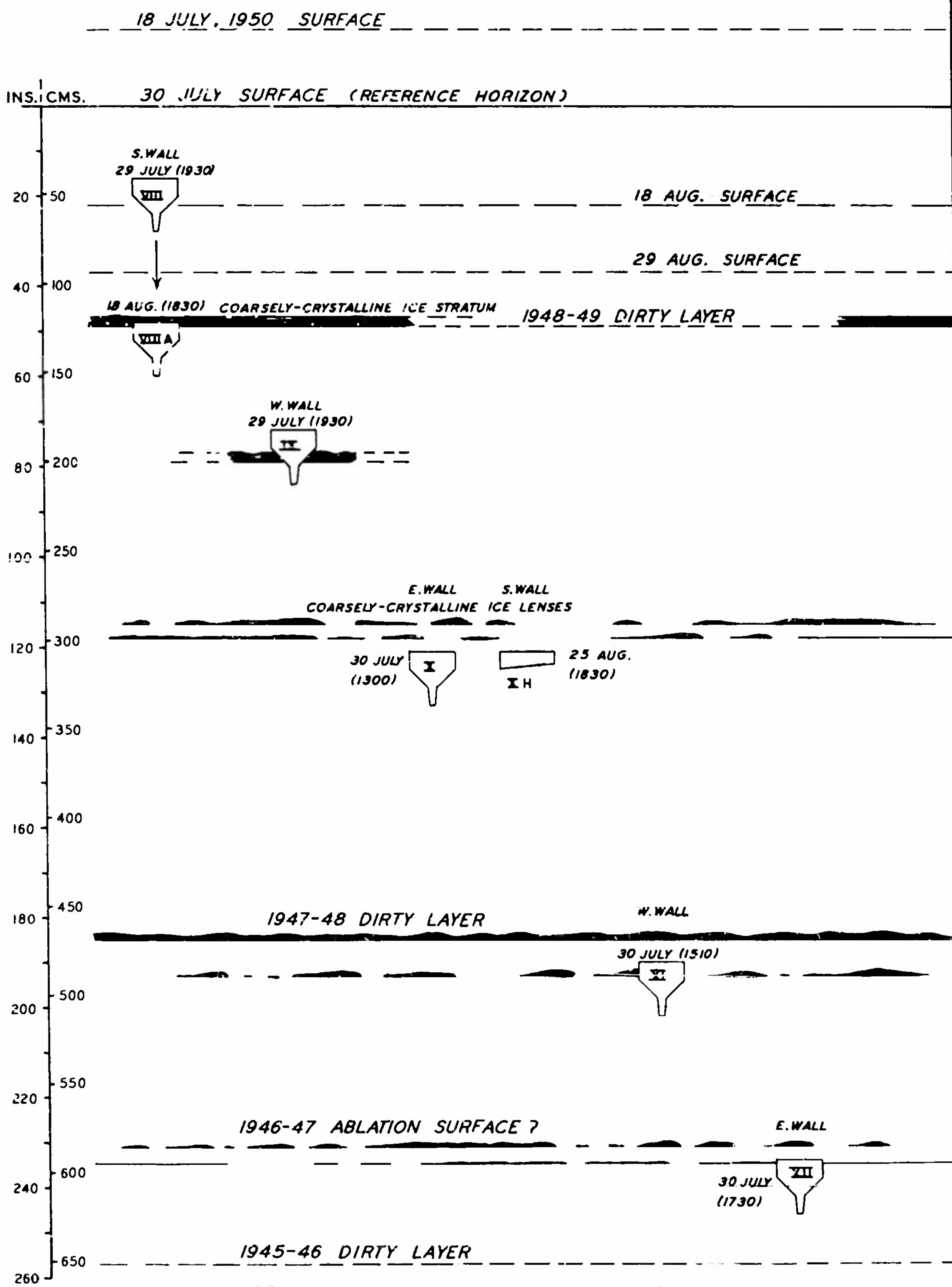


FIG.12 POSITION OF PERCOLATION PANS
PIT C, CAMP 10B, 1950

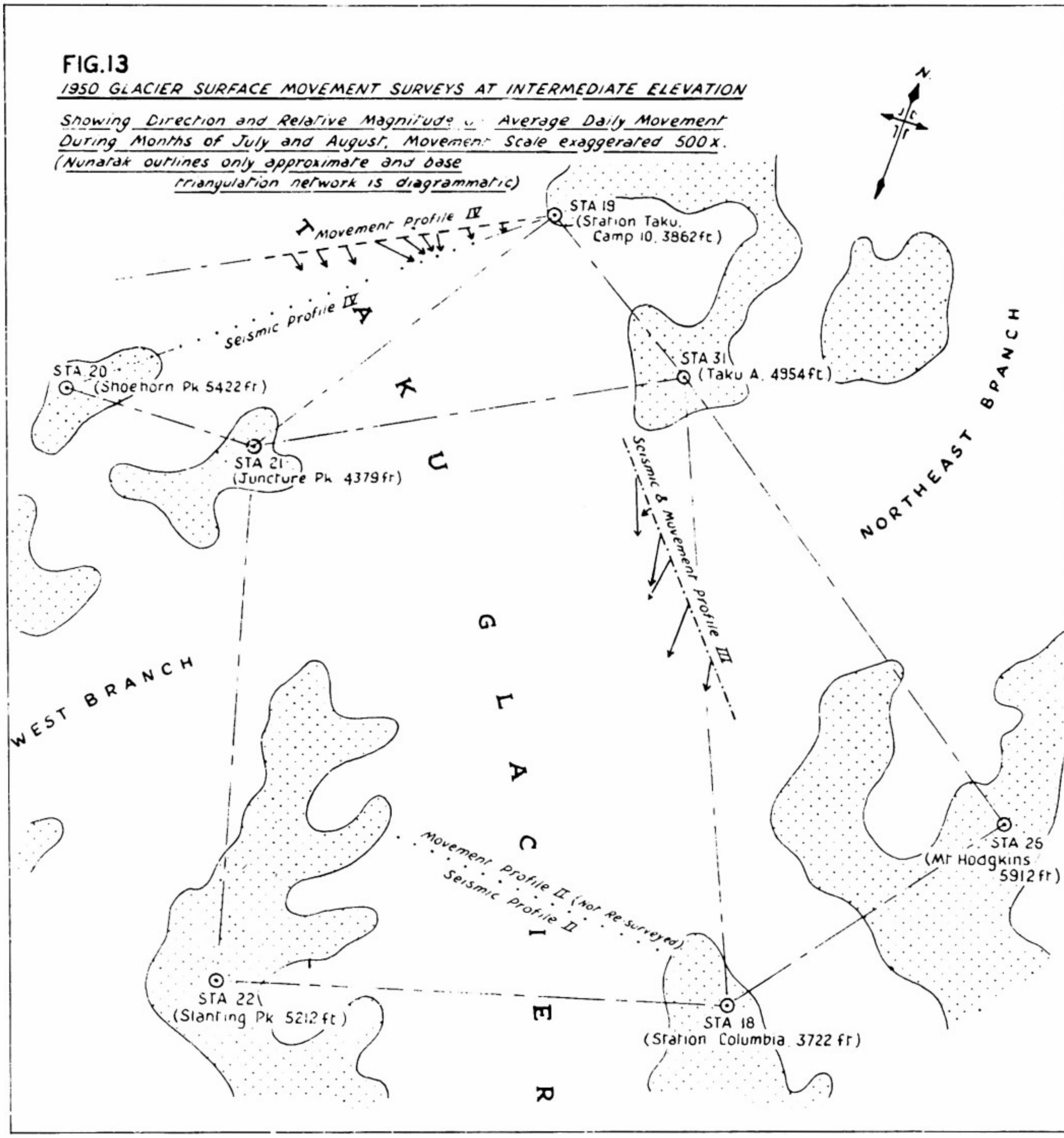


FIG.13

1950 GLACIER SURFACE MOVEMENT SURVEYS AT INTERMEDIATE ELEVATION

Showing Direction and Relative Magnitude of Average Daily Movement During Months of July and August. Movement Scale exaggerated 500 x. (Nunatak outlines only approximate and base triangulation network is diagrammatic)

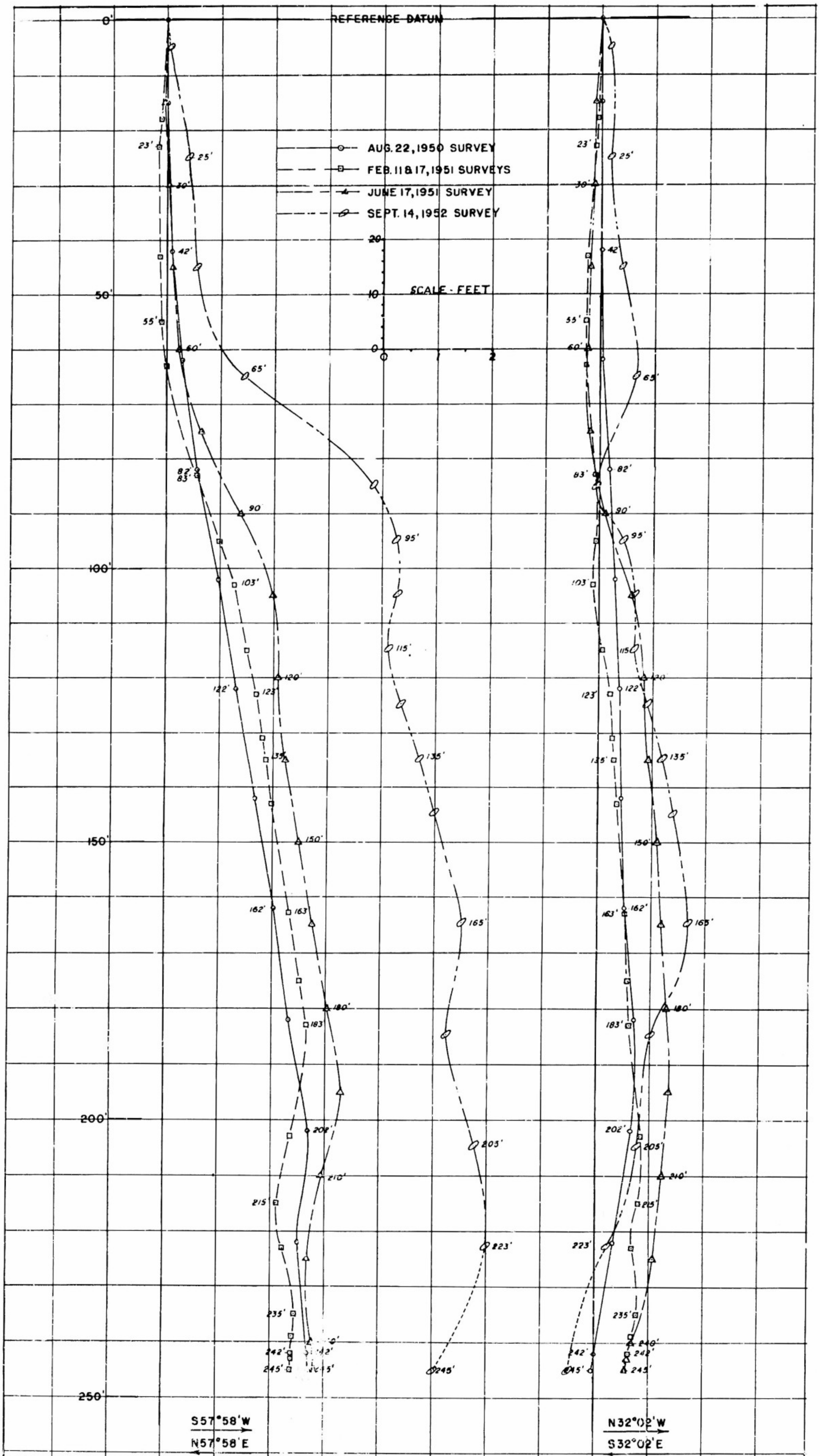


FIG. 14 BORE HOLE SURVEYS 1950-1952
VERTICAL PROJECTIONS

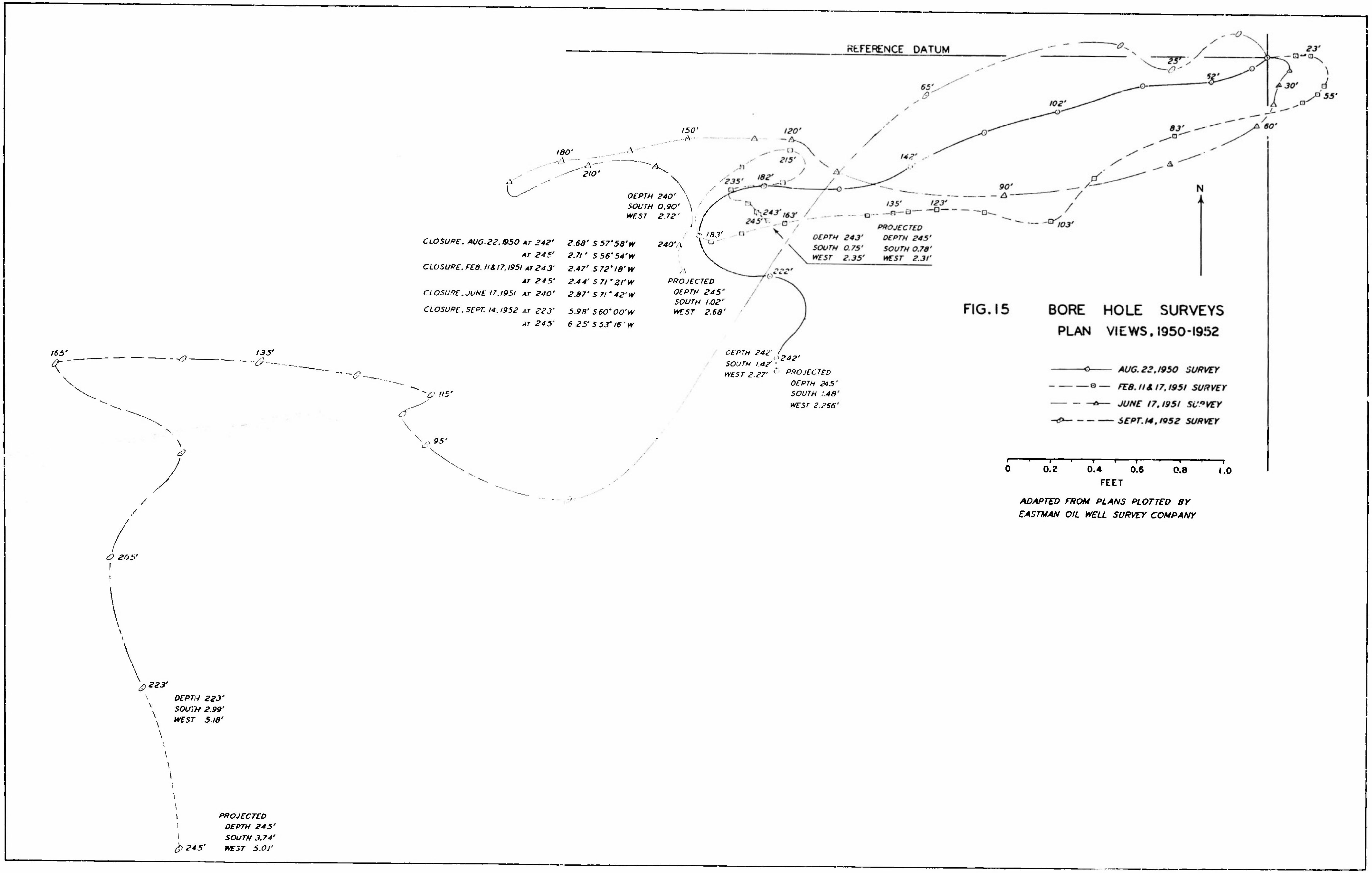


FIG. 15 BORE HOLE SURVEYS
PLAN VIEWS, 1950-1952

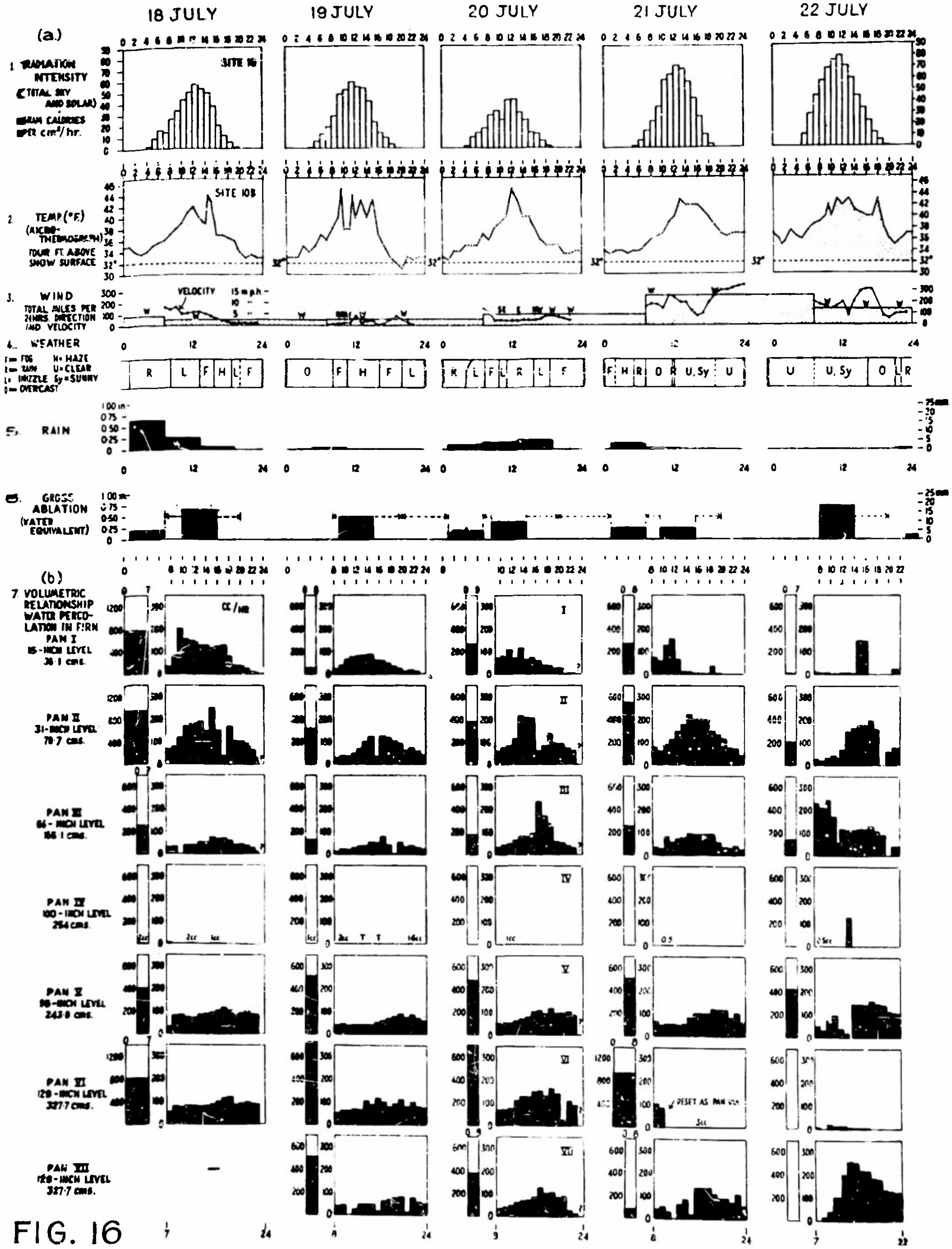


FIG. 16

(a) METEROLOGICAL FACTORS *IN THE INTRODUCTION OF MOBILE WATER IN THE TAKU GLACIER FIRN AT SITE 10B OVER A FEW DAYS IN JULY 1950 (1 TO 6)*

(b) DAYTIME, HOURLY PERCOLATION, (VERTICAL COMPONENT) *AT DIFFERENT LEVELS IN THE FIRN, SHOWING VOLUME RELATIONSHIP OF TOTAL WATER (cc) COLLECTED AT NIGHT BETWEEN DESIGNATED HOURS (7)*

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